

The AMSAT Journal

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The UO-22 Earth Imaging System

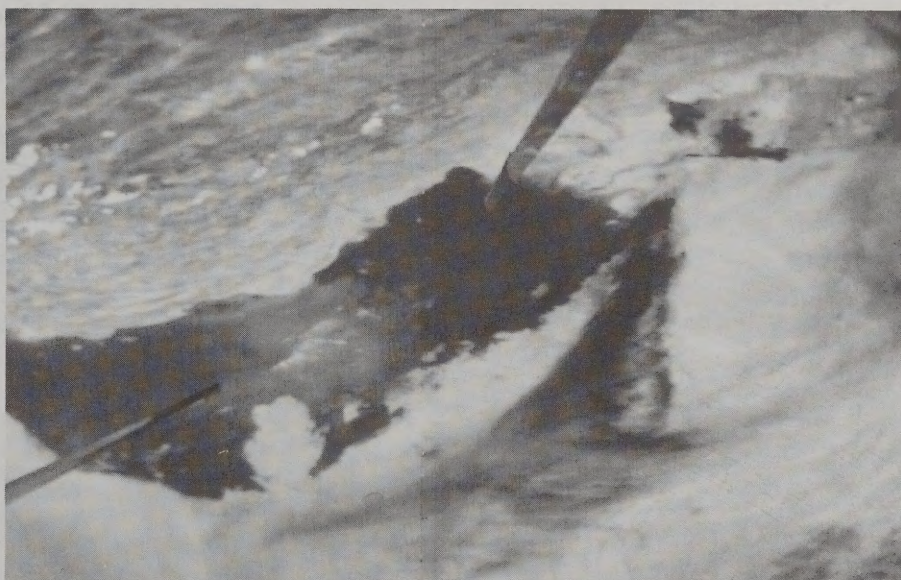


Photo by Dr. Martin Sweeting, G3YJO
Shot of the Persian Gulf. The black wisps to the left of the Gulf are from the burning oil fields in Kuwait.

By: Jeff Ward, G0/K8KA
University of Surrey

On July 17, 1991, an Arianespace rocket carried the remote sensing satellite ERS-1 and four 'microsatellites' into a 790 km sun-synchronous polar orbit. One of the microsatellites was UoSAT-OSCAR-22 - the fifth OSCAR satellite built at the University of Surrey. UO-22 is a multi-mission satellite, built partly to carry on the experimental program of the failed UoSAT-OSCAR-15 and also to provide store-and-

forward communications for SatelLife (a non-profit humanitarian organization which will use non-amateur frequencies).

UO-22 uses the same satellite 'bus' as UO-14 but packs in more experiments and more memory. The increase from 4 Mbytes of RAMDISK to 13 Mbytes was made possible by advances in CMOS memory density. We also wanted to add an Earth imaging system and a Solar Cell Technology Experiment, so something had to be removed from the UO-14 stack. The

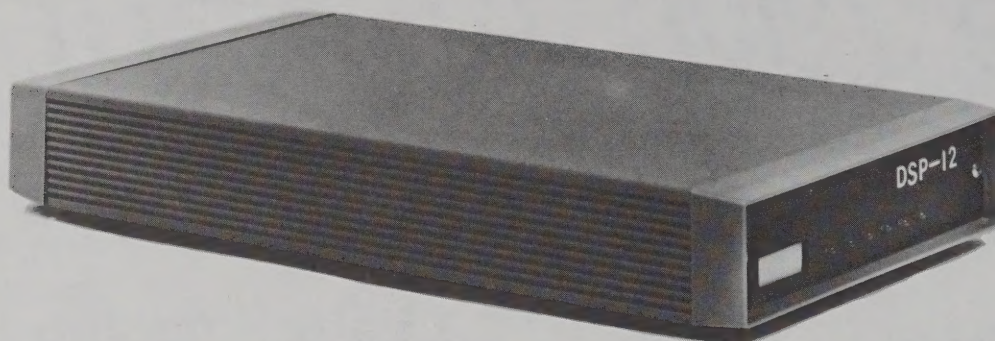
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Apogee View

'Tis the season

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As this time of year rolls around our thoughts turn to those things that we have done in the past year and inevitably we critique and plan to do better next year. We also pause to reflect on the holiday season and the spirit of giving that usually pervades this time of year. For the next few minutes let's reflect on those items as they relate to our hobby of ham radio and the organization that supports our little corner of that hobby, AMSAT.

As an organization, AMSAT has done a lot in the few years. We have realized a dream that has long smoldered in our minds - that of a satellite that can effectively carry large files from one station to another half way round the world in a matter of hours. Our success was so unique that commercial and other public service groups are using this technology that AMSAT pioneered. The dramatic recovery of DOVE, accomplished by combining the resources of AMSAT volunteers, was very close to being a miracle. I don't believe any other organization other than AMSAT would have had the resourcefulness, resolve and talent to perform such a rescue.

And maybe most notable of all AMSAT has committed in this last year to the most significant project the organization has ever undertaken. We along with our international AMSAT partners are going to orbit Phase 3-D, dubbed the Falcon. Those of us fortunate enough to attend the Symposium in LA recently were totally awe-struck at the size and scope of this majestic bird as we walked around the full scale model of the Falcon. You had to almost yell to be heard from the end of one of the solar panels to the other end more than 25 feet away. Certainly a MAJORSAT.

These accomplishments and others of note, such as satellite tracking programs for home computers, are here for us to enjoy because a small group of volunteers cared enough to give of themselves to make these seemingly impossible tasks happen. AMSAT's history is the story of very talented people volunteering large amounts of their time so that the others of us can enjoy whatever blocks of time we have for the hobby using our exciting resource. As we reevaluate the way we spent the previous year and look for-

ward to 1992 let's take a few minutes to consider what each of us have given back to the organization. After all - it is the season for giving.

Those individuals who have worked so long and hard to give us the operating satellites are truly a unique group of hams. Their talents seem almost endless. The rest of us may wonder what we can give to an organization with others who are so talented. Before you quit reading at this point - no - this is not a pitch for money, it is a request for some of your time. As AMSAT embarks on Phase 3-D we are all going to need to pull together in order to get this program to launch. AMSAT's first line of contact with its members and prospective members is its Area Coordinators. Being an Area Coordinator is something any AMSAT member can do as it only takes a telephone. The Area Coordinator's first and foremost responsibility is to be available to answer a question about the Amateur Satellite Program. Doing other things like having a local net or hosting a table at the local hamfest is ideal but all that we ask is to be available to answer questions. Yes, I realize that you probably won't be able to answer all the questions that may come your way but the important thing is that priceless quantity of time again. Take the time to call some of your fellow Area Coordinators and get the answer and get back to the member or prospective ham that wanted to know bad enough to call you. Area Coordinators belong to AMSAT's Field Organization: this same organization is now working on a Q&A book to give each of the Area Coordinators so they will be better prepared to face such questions and get them promptly answered.

So what will all this accomplish? Well let's go back to the spirit of giving. If you will give some of your time to become and be an effective Area Coordinator AMSAT will continue to grow. This continued growth will put us in much better shape to face the challenges both financial, technical and administrative of Phase 3-D. In short it will enable AMSAT to continue to give to the Amateur community. Isn't that what this season is all about?

If you are interested in becoming an Area Coordinator please drop me a line and I'll send you an information packet. The satisfaction you will get out of serving your fellow Amateurs will repay your investment of time handsomely. Thanks, 73's and may the holiday season find you and yours healthy and ready for the future.■

UO-22 Earth Imaging System

(continued from page 1)

solar cell experiment replaced the 1/2 board UO-14 Cosmic Particle Experiment, and to vacate an entire module box for the Earth Imaging System, we removed the venerable 1802 on-board computer (OBC). The new 80C186 OBC, first flown on UO-14, is now the primary UoSAT OBC. Switching to the 80C186 and using the software already tested on UO-14 made it possible for us to fully commission UO-22 within one week of launch - including extending the gravity-gradient boom, stabilizing the satellite, and taking the first pictures of the Earth.

For radio amateurs, the most important payload on UO-22 will be the Earth Imaging System, or EIS. The EIS hardware was designed and constructed at UoS by Ph.D. student Marc Fouquet. The Transputer software currently running on the image processing experiment was written by Chris Laker, a Master's degree student, who worked at UoSAT for one year. This paper is a technical introduction to the UO-22 EIS. It should provide enough information for programmers to write image display programs and for users to understand the capabilities of the system.

The EIS hardware is two separate circuits: a Transputer Image Processing Experiment located in the main UO-22 module stack, and a CCD Camera Head which looks out the bottom of the satellite.

The Camera Head

The Camera Head contains the charge coupled device (CCD) chip which converts light to charge, the timing circuits which drive the CCD, and an analog to digital conversion circuit which converts the CCD's analog output to digital pixels. The Camera Head is based on the CCD04-06 monochrome television sensor made by the EEV company. The CCD has 578 X 576 imaging pixels arranged as two interlaced fields of 578 X 288 pixels. (The exact image format is described later in this paper.) The pixels are rectangular, with an aspect ratio of 4:3 (horizontal : vertical). The sensor includes anti-blooming and electronic integration controls, which should improve overall image quality when compared to the UoSAT-1 and UoSAT-2 CCD cameras.

The output from the chip set is a CCIR 625-line TV signal which is digitized for storage and transmission. An 8-bit half-flash ADC provides 256 digital pixel values. (Higher numbers are brighter pixels.) Since the Camera Head circuit was custom-designed, all CCD timing signals are available, and the digitization of the TV signal is precisely timed to sample each im-



Shot of NE Egypt, Nile River and delta, Red Sea.

Photo by Dr. Martin Sweeting, G3YJO

age pixel correctly.

The Camera Head is connected by a parallel interface to the Transputer Image Processing Experiment. When the Transputer instructs the Camera Head to capture an image, a DMA (direct memory access) circuit transfers the digitized pixels over the parallel bus into the image RAM. The image RAM is multi-ported, and can be accessed by the Camera Head DMA circuit or by either of the two Transputers.

The Camera Head is located in the battery module box, at the bottom of the UO-22 stack. A 4.8 mm wide-angle lens looks out through the box toward the Earth. This lens, and the 10.6 mm diagonal of the CCD, gives a 96 degree cone of view from the satellite. From UO-22's 770 km altitude, this would result in a field of view with 1855 km diameter. Of course, the sensor is rectangular resulting in an image that is approximately 1500 km by 1100 km. Calculating the exact nature of the coverage zone, given that the CCD is 8.5 mm by 6.3 mm, is an interesting exercise in optics and spherical geometry.

The lens has fixed focus and fixed aperture. The Transputer module adjusts 'exposure' by changing the integrating time of the CCD, and the high and low thresholds of the ADC, thus altering the ADC gain.

An orange (605 nm - 615 nm) filter optimizes the monochrome image for contrast between water and arid land.

The Transputer Module

Transputers are microprocessors designed for high-speed parallel processing. As well as a central processor, integer mathematics unit and floating point unit, each Transputer chip contains four 10

Mbit/sec serial communications links which can be connected to other Transputers. The hardware architecture is closely linked to a software model in which parallel processes communicate over links. Transputers are particularly useful for naturally parallel tasks such as image enhancement and compression.

The UO-22 Transputer Image Processing Module contains two T-800 Transputers (T0 and T1). T0 runs at 17.5 MHz and is connected to 16 kBytes of Silicon on Sapphire (SOS) RAM. This RAM is 'immune' to single-event upsets (SEU), and can be used without error detection and correction (EDAC) circuits. T1 runs at 20 MHz, and has 2 Mbytes of 'normal' CMOS SRAM with hardware EDAC. T0 and T1 are linked by redundant Transputer links for parallel processing experiments. Both Transputers can access the image memory and control the Camera Head.

The Transputers communicate with the uplink and downlink through the primary 80C186 OBC. The OBC and the Transputers are linked on the satellite's serial data sharing (DASH) network, which currently runs at 9600 bits/second.

The Transputer module now runs a multitasking operating system written by C. Laker in Occam - the 'native' programming language for Transputers. This operating system allows T1 to simultaneously maintain a list of picture taking events, monitor memory performance, and transfer images to the OBC. The operating system provides flexible 'hooks' which will be used to add experimental image-assessment and image-processing routines.

Data Flow

The UO-22 picture taking process is

flexible, but complex.

At UoS:

- 1 - UoS Operators choose a picture time
- 2 - Request uploaded by AX.25 to 80C186 OBC

Onboard UO-22:

- 3 - Request transferred over DASH network to Transputer
- 4 - Transputer sets Camera Head and takes picture at appropriate time
- 5 - CCD data moved by DMA into Transputer image memory
- 6 - Transputer adds Image Header to CCD data
- 7 - Image Header+CCD Data transferred over DASH to 80C186
- 8 - 80C186 adds PACSAT File Header.

At User Groundstation:

- 9 - PACSAT format file downloaded using PACSAT Broadcast Protocol
- 10 - PACSAT File Header removed
- 11 - Image Header removed
- 12 - CCD Data converted to display format and displayed.

First, the operations team at UoS use the graphical tracking mode in InstantTrack to search forward in time for interesting image opportunities. When the desired picture times have been collected, they are sent, using an AX.25 packet link, from the groundstation to the Housekeeping Integration Task running on the 80C186 OBC. The OBC immediately forwards these requests over the DASH network to the Transputer operating system.

At the correct time, the Transputer sets the Camera Head to the desired gain and integration values, uploaded from UoS as part of the image request, and snaps the picture. The DMA hardware takes over and transfers the CCD Data from the Camera Head into the Transputer image memory. The Transputer adds an Image Header to the raw image, and transfers this data over the DASH network to the 80C186. This 9600 bits/second DASH transfer takes several minutes.

The 80C186 places the image and the Image Header into a file, adding a standard PACSAT File Header.

At this stage, the picture file is available for downloading. The OBC186 periodically transmits an 'Image List:' beacon showing the file numbers of the ten most recent image files. Any groundstation using the PACSAT Broadcast Protocol can then download the files. The broadcast downloading protocol is the same as that

used on PACSAT, LUSAT and UO-14 - no special software is required.

Image files are over 340 kbytes long, so efficient operating practices are important during downloading. Keep your station on in 'grab all' mode as much as possible - capturing all of the image packets which are broadcast. Then use the 'hole fill' procedures to get the parts of images which you have missed. If you have a good receiver and cooperate with others sharing your footprint, you may be able to download a new image in only one pass, though it may take several passes over congested areas with several users working on several pictures.

Once a picture file has been downloaded, the PACSAT File Header and the Image Header must be stripped off, and the actual CCD Data prepared for display. The PACSAT File Header should be removed with a utility, such as PHS.EXE, routinely used for PACSAT communications. After the PACSAT File Header is removed, you should have a file called 'IMxxxx', where the 'x's are replaced by a hexadecimal image number. The IM file contains the Image Header and the CCD Data.

Image Header

The first 256 bytes in an IM file contain the Image Header. The format of this header may change during experimentation, but it will always be a constant 256 bytes long. These bytes can either be discarded or interpreted according to the following data structure:

```
struct CCDH_TAG {
    time_t start_time;
    time_t take_time;
    unsigned long image_number;
    unsigned long retries;
    unsigned long set_image_num;
    unsigned char integration;
    unsigned char gain;
    unsigned char unused[233];
    unsigned char version;
} ccdh;
```

Multi-byte values are stored least-significant-byte first. The variable `time_t` is four bytes counting the number of seconds since 1/1/80; long is four bytes; char is one byte. There are no slack bytes within the structure.

start_time — is the scheduled time for the picture.

take_time — is the time that the picture was actually taken.

image_number — is the image number (as used in the IMxxxx file name).

retries — currently unused, will be set by adaptive exposure software to show how many images were discarded.

set_image_num — not zero if command

station was resynchronizing image numbers.

integration — zero is the longest integration, with increasing numbers indicating shorter integration times. The range of integration times is from 20 msec to 2 msec.

gain — is two 4-bit numbers. The least-significant nibble sets the low voltage threshold of the ADC, and the most significant nibble sets the high voltage threshold. Between these two thresholds 256 pixel values will be assigned. Changing the values can expand or compress the camera's range to better fit a particular scene.

unused — is space reserved for future use

version — is the last byte of the header. The current version is 0x80. We will attempt to make future headers upwardly compatible with version 0x80, by assigning meaning to currently unused bytes.

CCD Data

Once the Image Header has been removed, only the CCD Data remains. This is the contents of the CCD, stored as a sequence of horizontal scan lines. Unfortunately, the CCD Data is not a simple raster image. Instead, it is divided into three sections: the 288 even lines, followed by 355 bytes which must be discarded, followed by the 288 odd lines. Each line is made up of 611 pixels as follows:

```
Line 0
Line 2
Line 4
...
Line 574
Discard 355 bytes
Line 1
Line 3
...
Line 575
```

When the image is displayed, the lines should be interleaved as follows starting from the top of the image:

```
Line 0
Line 1
Line 2
...
Line 575
```

With the lines interleaved correctly, the image can be treated as a two dimensional array of 576 lines by 611 pixels. This is a raster image, which can be displayed on your screen or used as input to further image processing and format-changing programs.

Displaying UO-22 Images

A relatively high quality graphics system is needed to display the entire UO-22 CCD image. In particular, the system should display 64 or more shades

of grey. For MS-DOS users, this means at least a VGA adapter, and a Super VGA with 800 X 600 X 256 is much better. Mapping the image to fewer grey levels will obscure the interesting detail in the pictures. Of course, it is best to have the full image on the screen, but if you have to trade off resolution against grey levels, go with the latter.

Users have taken two approaches to image display. Some have converted the raster array to the standard Graphics Interchange Format (.GIF) and displayed the image with public-domain shareware or commercial GIF viewing programs. Others have written their own programs to manipulate and display the raster image. Each approach has advantages and disadvantages.

The .GIF format is popular, and .GIF viewers are available for most computers - from Sun workstations to PCs. Once someone has converted one of UO-22's images to .GIF format, the image can be widely distributed and viewed. GIF copies of the best UO-22 images frequently show up on the UO-14 mailbox, CompuServe, and the Internet. Some GIF viewers provide flexible contrast control, stretching, and image enhancement. Unfortunately, others are extremely simple and cope disappointingly with the wide dynamic range of the UO-22 pictures. Some sources of shareware .GIF viewers and utilities are listed at the end of this paper.

Writing your own display program is rewarding, but time consuming. It gives you the best control over the finished image, allows you to get the most from your particular computer and display, and educates you. The best current example of this approach is DISPLAY4.EXE by Colin, VK5HI, which works on IBMs. This program is distributed as freeware, and usually available on the UO-14 mailbox.

Interpreting and Enhancing Images

Once you have displayed an image, you have to interpret it. In some cases, geographical features will be so stunning that identification will be obvious. Usually, however, some contrast enhancement will be needed to bring your display's 64 grey shades into the most interesting part of the picture, then you have to get out a tracking program and an atlas to identify Earth features.

Some fixed features will become familiar to you as you experiment with UO-22 images. The two bands extending diagonally into the frame are the satellite's antennas. If the image shows a large body of water, you may see the sun's reflection making the water brighter than the land (a reversal of the normal contrast). Sometimes

(less and less frequently), you may see the limb of the Earth, indicating that the UO-22 attitude control routines are out of tune. Towards the edges of the picture - and particularly when these coincide with the limb of the Earth - geographical distortions become noticeable. Of course, since UO-22 spins around its Earth-pointing axis, North won't always be to the top of the image!

In general, picture quality is excellent, as shown by the photos accompanying this paper. Contrast between land and sea is high, and the 2-km resolution can be confirmed by examining coastlines and islands. Identifying scenes without reference to satellite tracking software can stretch one's geographical knowledge, but once the sub-satellite point and angle of rotation have been determined, prominent features should be easily located with the aid of an atlas.

After looking at raw images, you'll probably want to try some image processing. If you write your own display program, you can implement your own image processing algorithms and tightly integrate processing and display. If you use the GIF route, you can still perform processing on the raster array before conversion to GIF. In either case, your first job will be to get rid of known anomalies in the UO-22 images.

Duplicated Dash Packets

For a combination of reasons, the communications protocol on the DASH link sometimes duplicates packets between the Transputer and the 80C186 OBC. This causes a 1-packet-long portion of the Image Header or CCD Data to be repeated. On early images, these repeated sections were 254 bytes long; the packet length was recently changed to 110 bytes. After removing the PACSAT File Header, you can look for any 110 byte repeated blocks and remove them. Be careful not to throw out areas of uniform pixel value; if all the pixels in a block have the same value, the block isn't a good candidate for removal. Fortunately, the repeated packet problem can be solved through modifications to OBC and Transputer software. It is on the decrease, and shouldn't be with us for much longer.

Pre-Image Slack

When the pixels are clocked from the CCD sensor into the image memory, some initial non-image bytes are generated by the chip-set and stored by the DMA hardware. If these bytes are not removed, they will show up at the beginning of line 0; the end of line 0 will show up at the beginning of line 2, and so on, down the image. Because this is a constant offset, the image will not

be distorted, but will appear to have 'rolled' horizontally. Discarding 48 bytes after the 256-byte header moves the image to the left hand side of the screen, with all of the unused pixels showing up at the right hand end of each line.

Pixel Dropout

Because a relatively slow, low-power ADC was used in the Camera Head, the ADC cannot always follow the input video signal correctly. When the ADC cannot keep up, invalid pixel values are stored in the image memory. These pixel dropouts are usually on the right-hand edge of bright objects, and are either very bright or very dark pixels. Pixel dropouts can be removed with a 'median filter' applied to each line. This filter examines a pixel, and if that pixel is sufficiently different from its neighbors, sets the pixel to the median value of its neighbors. For best results, the filter is applied from right to left. It is worth experimenting with the threshold for dropout detection and with schemes for identifying two immediately-adjacent dropouts.

The White Line

On all images produced by the UO-22 CCD camera, two adjacent lines are significantly brighter than their neighbors, creating a horizontal white line across the image. A power surge in the CCD chip set during image capture causes this. Roughly speaking, a constant value has been added to all of the pixels in the line, and various schemes for removing this offset have been attempted. First, locate the white lines by searching for a discontinuity in the black reference band. Then calculate the average pixel value in each white line and in the last preceding 'normal' line. Finally, calculate the difference between the 'white line average' and the 'normal line average' and subtract this value from each pixel in the white line. This is not entirely successful, but does reduce the impact of the horizontal stripe.

Low-Level Noise

It is inevitable that some noise creeps into the analog signals as they are amplified and sampled in the Camera Head. There are no simple filters to eliminate this noise, which is only a bit or two in amplitude. Beware of this noise when using extreme contrast enhancement, and when viewing images with very low exposure.

Conclusion

After looking so closely at the blemishes on UO-22's CCD output, we should step back and look at the stunning results! Although the photos don't show

the true detail of the original images, they give an idea of what UO-22's camera can do. Photo 1, taken over the Persian Gulf, clearly shows a plume of black smoke blowing south from the burning oil fields of Kuwait and over the Saudi desert. Photo 2 shows the Gulf of Suez, the Nile delta and the Nile itself snaking into Egypt. These photos were taken from the screen of a Sun workstation running the XVIEW GIF viewer.

It is only a few months since the 5-day-old UoSAT-OSCAR-22 transmitted its first CCD picture - of Italy and the Mediterranean. Already, the scheduling, interpretation and processing of the images has been educational for the operators at UoS and the hundreds of others who have used UO-22's data. The UO-22 camera is an excellent example of how the Amateur Satellite Service can push the frontiers of low-cost satellite technology while providing excitement and education for radio amateurs equipped with affordable groundstations. ■

Resources: GIF format copies of the UO-22 images can be found on the GFRN BBS, courtesy of NK6K and WB6YMH. Look in MICROSAT directory. Phone 213-541-2503. Some are also

available on the Internet at tomcat.gsfc.nasa.gov.

RG8 is a raster file to .GIF converter available as shareware for MS-DOS machines. Registration is \$10 from Bob Montgomery, 132 Parsons Rd, Longwood, FL 32779.

DISPLAYn.EXE by VK5HI, will display UO-22 images on IBM-PC compatibles with some types of VGA cards. The best place to get DISPLAY is on the UO-14 mailbox.

A great PC compatible VGA GIF viewer with

lots of tools is IM-PROCESS.EXE, available as shareware: \$25 from John Wagner, 3550 E. Lake Mead Blvd, Apt 331, Las Vegas, NV 89115.

Further information on the PACSAT File Header, the PACSAT Broadcast Protocol, and the entire PACSAT protocol suite is available in the Proceedings of the Ninth ARRL/CRRL Amateur Radio Computer Networking Conference. Freeware (PG.EXE, PB.EXE and PHS.EXE) implementing the protocol suite is widely available.

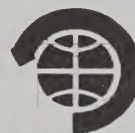
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A Report on the Design Principles of the Ariane 5 Launcher

By: Ron Long, W8GUS
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Columbus, OH 43221

Dick Jansson, WD4FAB
1130 Willowbrook Trail
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It is October 1995, just four short years from now, and with a little imagination you can see in Figure 1 our Phase 3-D (Falcon) spacecraft on its way to orbit aboard the powerful new Ariane 5 launch vehicle. If you like to plan ahead, clear your calendar because this is an event you won't want to miss. It promises to be the most significant amateur radio event of the decade.

What is Ariane 5? It is an entirely new more powerful launch system which has been under development by the European Space Agency (ESA) since 1988. Obviously it will be able to launch much heavier payloads than the earlier rockets in the Ariane fleet. For example it can launch two payloads of 3 metric tons (6,615 pounds) each into a geostationary transfer orbit at an inclination of 10 degrees, or a single payload of 6.9 metric tons (15,215 pounds) into a similar orbit. Among other exciting missions for Ariane 5 is the Hermes manned European space plane where it is required to inject Hermes and its resource module having a mass of 22 metric tons (48,510 pounds) into a 100 by 463 km transfer orbit at an inclination of 28.5 degrees.

Figure 2 shows a more detailed drawing of the Ariane 5 configuration. Like the NASA shuttle launcher the main stage consists of two side-mounted solid propellant boosters and a liquid propellant main stage. In the case of Ariane the cryogenic engine is a single motor fueled by liquid hydrogen and oxygen. Again like the shuttle, this main engine is started prior to liftoff and the solid boosters are ignited only after proper operation of the main engine has been verified.

Above the first stage there is a single liquid propellant rocket plus the payloads and fairing. In Figure 2 you can see the second stage rocket motor at the center of the drawing just above the main fuel tank.

A new launch site is under construction at Kourou especially for the Ariane 5. In fact most of the major buildings and facilities are nearly complete. This was necessary since the main engine and solid



Figure 1: Artist conception of Ariane 5 during launch.

Draying courtesy of ESA

booster development tests will take place at the launch site. A major change, compared to launch facilities for the Ariane 4, is the replacement of the mobile gantry with a permanent building. This Final Assembly Building provides facilities for final launcher checkout and integration of payloads on the launcher. The launcher remains inside the BAF building until it is moved forward to the launch zone on its mobile table for filling and the final phase of the countdown. The ELA-3 site also includes a production plant for liquid oxygen, nitrogen and hydrogen.

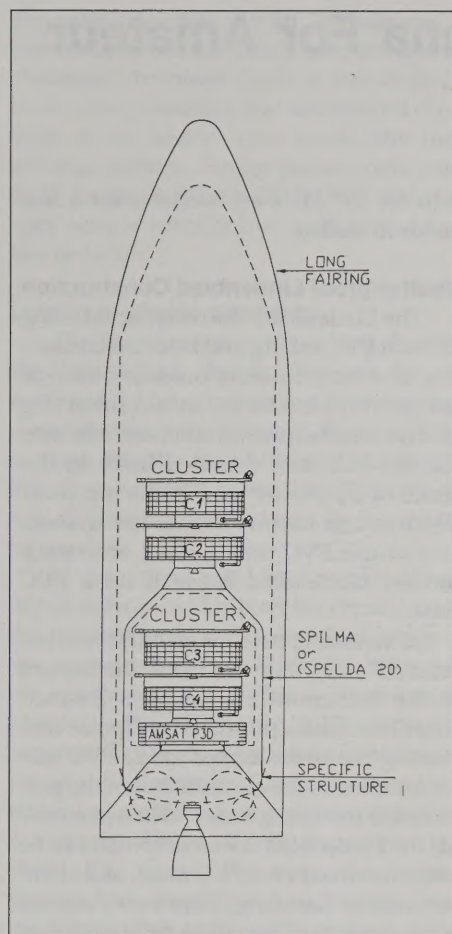
For Ariane 1 through 4 the reliability objective was 0.9. Because of the higher costs of the anticipated payloads, the objective for Ariane 5 is 0.985 for the entire vehicle and 0.99 for the first stage. Additional considerations for the Hermes manned flights which are to commence in 1999 result in a safety objective of 0.999.

The first stage main engine has the hydrogen and oxygen turbopumps driven in parallel by a common gas generator. Each solid propellant booster consists of three propellant-filled segments which are

joined together. The steel case is made of 7 cylindrical sections which are joined together and a nozzle which has a flexible bearing. Thrust direction can thus be varied by up to 6 degrees. Each booster is 3.03 m in diameter and 30 m long. The solid boosters build on the experience gained in the NASA shuttle program. There will also be ten full scale development tests.-

For launching conventional satellite payloads, such as Phase 3-D, Ariane 5 is assembled using an upper stage that is a composite of a number of components, with multiple options on the use of these components. This upper stage consists of a storable propellant, restartable "L7" propulsion unit, with attendant equipment bays, etc.

Housing of multiple payloads on top of the L7 unit is done on Ariane 5, much as is done on the earlier Ariane launchers. using structures that support the upper payloads while, at the same time, providing a cocoon for the lower payloads. On Ariane one such structure, called the SYLDA was used on the OSCAR-10



launch and the support structure is completely contained within the aerodynamic shroud protecting all of the payloads. Another structure, called SPELDA was used on the launch of OSCAR-13, provides its own shrouding of the lower payloads. In turn, a short aerodynamic is mounted on top of the SPELDA to protect the upper payloads. All of the purely aerodynamic shrouds are jettisoned as soon as the Ariane has enough altitude beyond the sensible atmosphere.

Ariane 5 has its own compliment of larger sized multiple launch support structures, all with their own unique names. For the AR502 launch of the Falcon spacecraft, the internal cocoon concept will be used, much as with the SYLDA for OSCAR-10. In this case, however, ESA may use the (formerly external) SPELDA structure for this launch, purely as an internal cocoon support, along with the Ariane 5 external support. This is mostly because the SPELDA design is available, while its Ariane 5 equivalent, SPILMA, may not be ready for service. For reference, the Ariane 5 equivalent of the external load bearing and aerodynamic protecting SPELDA, will be the SPELTRA. The interfaces of Falcon and the four Cluster spacecraft with the AR502 launcher are all designed to accommodate the use of either the SPELDA or the SPILMA. ■



Figure 2: Cross-section of Ariane 5 launch vehicle

Drawing courtesy of ESA

A Lindenblad Circularly Polarized Antenna For Amateur Satellite Communications

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Introduction

This article describes the construction of a Lindenblad circularly polarized antenna for microsat communications. In particular, the design is for satellite downlink communications at 436 MHz; however, theory and construction practice show that the design can be easily scaled to 146 MHz for ground station uplinks.

Lindenblad construction has previously been described in the *Satellite Experimenter's Handbook* and in *The AMSAT Journal*^{1,2}. The design here overcomes some practical problems described by Howard Sodja (W6SHP) and Stu Mitchell (WD4ECK)³. These problems are: (1) 50-ohm impedance matching difficulties, and (2) interaction effects of the 300-ohm twinlead half-wave phasing lines. The design described here also provides weather protection for long-term outdoor installation.

In practice, low SWR (below about 3:1) is not required for receiving antennas, especially when low-noise amplifiers are used (except, for example, when impedance mismatch will result in LNA oscillation). A design frequency of 436 MHz (a typical downlink receiving frequency) was chosen because the size of the Lindenblad is small enough for construction and measurement in the workshop.

"Omnidirectional" Satellite Antennas

There are a number of "omnidirectional" antenna types which are suitable for microsat use. Such antennas include the discone, ground plane, Lindenblad, quadrifilar helix, turnstile, and vertical. These antennas generally have low gain and are omnidirectional in azimuth, but have differing gain properties in the elevation plane. The discone, ground plane and vertical tend to have main lobes at low elevation angles; the Lindenblad at low to intermediate angles; and the turnstile at intermediate angles. The quadrifilar helix can be nearly omnidirectional in both planes, but is the most difficult to construct⁴. Of course, of these antennas, only the Lindenblad and quadrifilar helix are circularly polarized.

The optimum microsat antenna to use depends on observer location and the distribution of elevation angles for a given set of satellites; one solution is to have several different antennas with the ability to switch between them as needed. At the author's latitude (San Francisco bay area), published elevation radiation patterns for the Lindenblad suggest that it would be an excellent choice for microsat links. The low cost and suitable radiation pattern of the Lindenblad at VHF and UHF frequencies make it quite attractive for microsat applications.

The quadrifilar helix would also be a good choice, but presents more difficult construction problems. At 146 Mhz, the quadrifilar helix is an extremely compact antenna compared to the Lindenblad. Commercial versions of the quadrifilar

helix for 137 MHz are available for a few hundred dollars.

Weatherproof Lindenblad Construction

The Lindenblad was constructed using 1/2-inch PVC tubing and assorted connectors, and an aluminum outdoor electrical box pre-threaded for 1/2-inch conduit (Fig 1). The weatherproof aluminum box also has one-half inch threaded holes in the center of the bottom and in the top cover which can be used to mount the antenna on a simple PVC tubing stand or to stack another Lindenblad above it on a PVC mast.

A mounting hole for an N(f) weatherproof RF connector was cut in the bottom of the aluminum box using a 5/8-inch Greenlee chassis punch. The dipoles and phasing lines were located inside PVC tubing attached to the electrical box at the pre-threaded mounting holes. When assembled, the Lindenblad is weatherproof, can be easily mounted on a PVC mast, and is impervious to handling; *there are no exposed dipoles or phasing lines which could move from their intended locations*. In addition, the aluminum box may provide some RF shielding.

Dipole Elements and Phasing Lines

Folded dipole elements were made of 300-ohm, foam-filled twinlead from a local hardware store, and the phasing line sections of RG-188 (50-ohm) coaxial cable. RG-188 has a teflon dielectric and outer covering which permits soldering to the center conductor and braid without untoward effects. Furthermore, it is small in diameter and can be coiled neatly inside

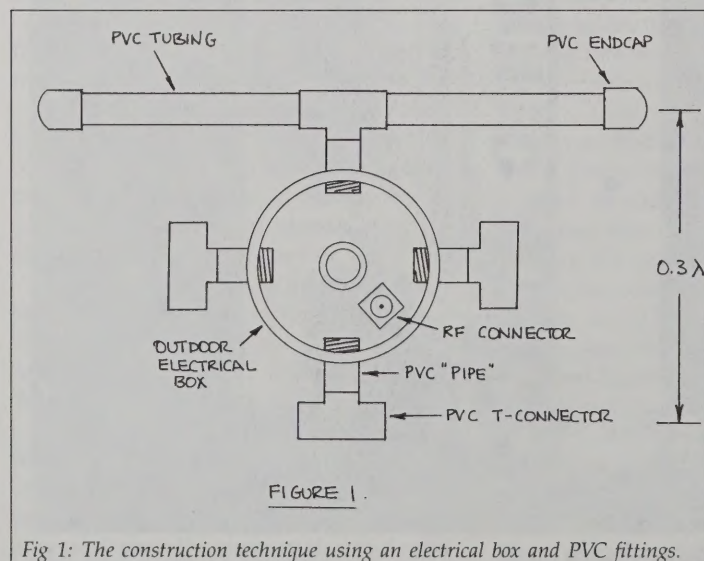
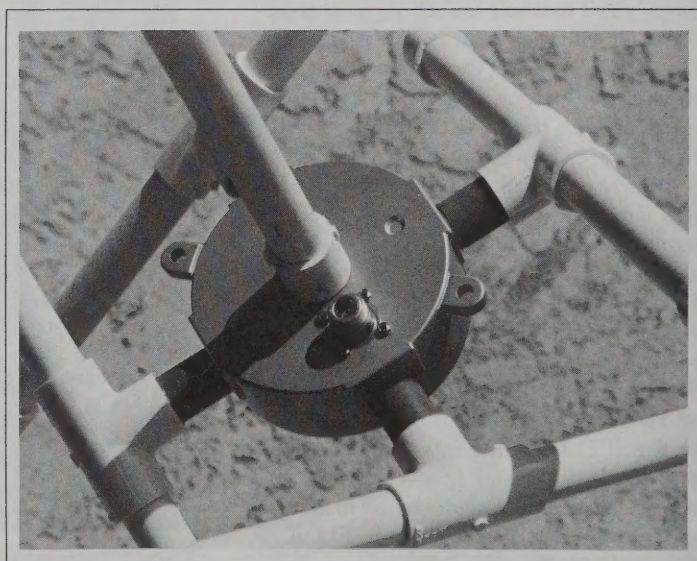


Fig 1: The construction technique using an electrical box and PVC fittings.



the aluminum box. As an "unbalanced" coaxial transmission line is connected to a "balanced" twinlead dipole in this design, there is the possibility that unbalanced currents in the 50-ohm coax could alter the radiation pattern. Design purists could use UHF ferrite beads on the RG188 coax (a very simple solution) or a quarter-wave sleeve balun.

Length of dipole elements

The first question was how long should the Lindenblad dipole elements be at resonance? Mutual coupling between the elements affects the resonant frequency for a given length. In addition, the use of 300-ohm twinlead, rather than #12 wire or 1/4-inch tubing, also changes the resonant frequency.

A prototype was constructed using 300-ohm twinlead for both the dipoles and the phasing lines, and its resonant properties measured with an HP8660C frequency synthesizer, a Wiltron directional coupler, and a Tektronix 7L13 spectrum analyzer. The resonant antenna impedance can also be determined by measuring the return loss. Initial measurements suggested a resonant folded dipole impedance of about 320 ohms. However, the scalar (return loss amplitude only) properties were somewhat confused by several close "resonances" involving the dipoles and the phasing lines.

Sometime later a packet radio message was received from Howard Sodja which said that he and Stu Mitchell were having matching problems with their design (based on a MININEC computer model), and that they had found interaction effects between the 300-ohm twinlead phasing lines which affected the measured SWR. Subsequently, I decided to purchase an HP8405A vector voltmeter and an HP778D dual-directional coupler to make amplitude and

phase measurements needed for studying the Lindenblad. These took several months to obtain, but were required in order to make heads or tails of what was happening.

Based on the interaction of the phasing lines reported by Howard and the difficulty I had in coiling the 300-ohm twinlead phasing lines (even at 436 MHz) inside the weatherproof aluminum box, I decided to attempt a design using miniature RG-188 50-ohm coax.

A second prototype was built using 300-ohm twinlead for the dipole elements and half-wavelength RG-188 phasing lines. Using this model, I determined the relationship between dipole length and resonant frequency is approximately (with 0.3-wavelength Lindenblad diameter and 30° dipole element tilt):

$$\text{Dipole element length} = \frac{14,300 \text{ cm-MHz}}{\text{Frequency}}$$

This is about the same as that for the 146 MHz Lindenblad design in the *Satellite Experimenter's Handbook* (14,050 cm-MHz/Frequency) which uses #12 wire to construct the folded dipoles. Stu's MININEC calculations suggested that the element length for 300-ohm twinlead should be longer than that for the #12 wire dipoles used in the *Handbook*.

Length of the Phasing Lines

A third prototype was built with dipoles intended for 436 MHz and half-wavelength RG-188 phasing lines. However, I miscalculated the dipole length and instead cut them for 448 MHz. When I measured the SWR, it was 1.05 at resonance - far below the value of 1.6 that I expected (320/4 ohms divided by 50 ohms).

When phasing lines are exactly a half-

wavelength long, the feedpoint impedance is the same as the load (dipole) impedance, regardless of the characteristic impedance of the half-wavelength line. A transmission line can be used as an impedance transformer whose input to output impedance ratio depends on the characteristic impedance of the line, the load impedance, and the electrical length of the line. The feedpoint impedance is given by ⁵:

$$Z = Z_0 (Z_a + Z_0 \tan \delta) / (Z_0 + Z_a \tan \delta)$$

where Z = impedance at the input to the line transformer

Z_0 = characteristic impedance of the line transformer

Z_a = impedance of the load (dipole)

δ = electrical length of the line transformer

When δ is 180 degrees (one-half wavelength), then $Z = Z_a$; when δ is 90 degrees, we get the familiar relation for a quarter-wave matching section: $Z_0 = \sqrt{Z Z_a}$.

When I misscut the prototype dipoles, this made the RG-188 phasing lines about 186-degrees long at 448 MHz. If the resonant impedance of the dipoles were 320 ohms, a line transformer length of 185.6 degrees would give an impedance of 200/4 ohms at the feedpoint, resulting in an SWR of 1.0. The 50-ohm RG-188 line transformer impedance ratio depends *critically* on the electrical length of the line: a six-degree change in length (only 7 mm at 436 MHz) alters the transformed feedpoint impedance from 320 to 200 ohms. An advantage of using 300-ohm twinlead for the phasing lines is that the length of the line is not critical when the dipole impedance is about 320 ohms (i.e. $Z_0 = 300$ ohms and $Z_a = 320$ ohms).

Another prototype was built with the dipoles properly cut for resonance at 436 MHz, and with 186-degree-long RG-188 line transformers. The measured SWR was

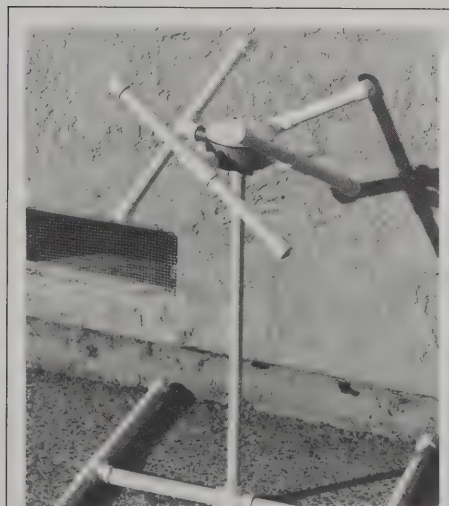
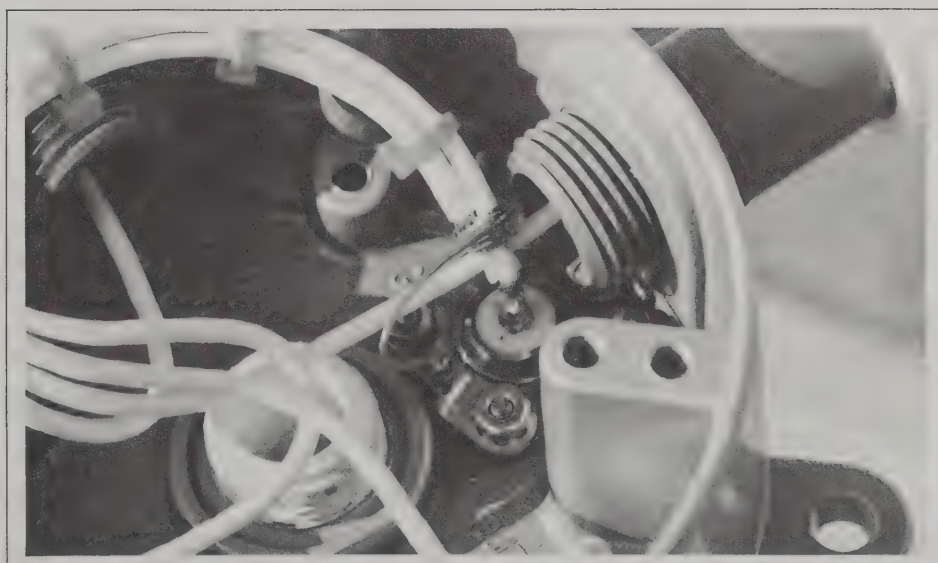


Photo by W6XY

Fig 5: The weatherproof Lindenblad antenna.



disappointingly high and the resonant frequency was about 430 MHz; I trimmed the dipoles to see if I could decrease the SWR at 436 MHz, but there was little change.

Being an occasionally rational person, I was upset that theory did not seem to match practice. After thinking about the problem, I came to the conclusion that I must have made another construction error. Yet another prototype was built to the same intended dimensions, but with exactly the same result. Using the phasing lines from the previous prototype, I carefully measured the electrical length with an HP8405A vector voltmeter and noted the sensitivity of the measurement to the exact location of the probe ground point. I was suddenly seized by the realization that I had not considered the lengths of the connections from the N(f) connector to the RG-188 line transformer input!

In my previous two prototypes, the center conductors of the four RG-188 coaxial lines were twisted together and soldered to the center pin of the N(f) connector; a single tinned bus wire had been wrapped around the braid of the four RG-188 lines, well soldered (ah, teflon!) and then connected to a ground lug at the N(f) connector. This ground wire was about two centimeters long (!) as I wanted to be able to remove the installation and trim lengths if needed. I pulled pieces of the "successful" 447 MHz Lindenblad from the trash can and noted that the ground connection at the braid had been made in a different way, although the lead length was still fairly long. I shortened the length of the ground lead of the latest prototype and noted a substantial change in the resonant frequency and SWR. I made further small adjustments until the resonant frequency was

about 436 MHz and the SWR was less than 1.2. Success was within reach, although I noted that there was some interaction between phasing lines and my hand with the aluminum cover removed. The ground lead could be adjusted for low SWR at resonance with the phasing lines (now line transformers) and aluminum cover in place - a slightly tedious process to make fine adjustments and reassemble for measurement.

Practical Lindenblad construction

The attached figures illustrate dimensions and construction of the 436 MHz Lindenblad.

The overall length of the folded dipoles was measured from the center of the bead formed when the leads of the twinlead were twisted and soldered together and the excess lead length trimmed off (Fig 2). The exact center of the element was determined with a scale and one line of the twinlead was cut at that point. After one element has been carefully measured and prepared, it is easier to construct three more identical elements by using the first as a standard, rather than by precisely measuring out each element separately.

The RG-188 coaxial lines were measured from the point where the braid and center conductor separated at the load to the end of the braid at the feedpoint (Fig 3). Allow sufficient conductor length beyond this measured length for attach-

ment to the folded dipoles and soldering to the N(f) connector as shown.

The coaxial lines were connected to the folded dipoles using short (about 1-cm long) butt-joint crimp connectors which were both crimped and soldered (Fig 4). The 300-ohm twinlead does not like to be heated, so *lightly* tin the crimp connectors and twinlead wires, crimp them together, then heat the crimp connector only long enough for the solder to melt between the connector and twinlead dipole. I used electrical tape to mechanically support the connection.

Cut a hole in the aluminum box and mount the RF connector on the bottom opposite the opening for the lid (Fig 1). N(f) and BNC connectors provide some weathertightness. Attach a solder lug at the RF connector for a later ground connection to the RG-188 braid. You can further moistureproof the N(f) connector by using stainless steel mounting hardware and several coats of clear nail polish around the edges of the connector inside the aluminum box.

Prepare four pieces of 1/2-inch PVC pipe threaded on one end and cut each so that the assembled diameter of the Lindenblad will be 0.3 wavelengths when measured from the centers of the PVC tubing elements. Three-way (slip-slip-slip) T-connectors are used to attach the threaded PVC pipe to the 1/2-inch PVC tubing used to hold the folded dipoles. PVC endcaps

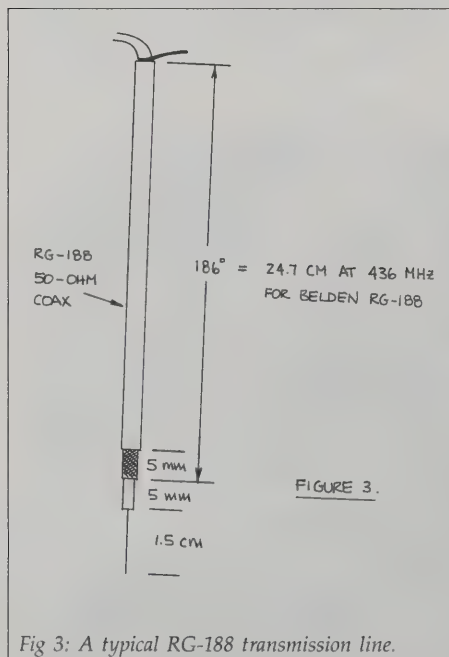


Fig 3: A typical RG-188 transmission line.

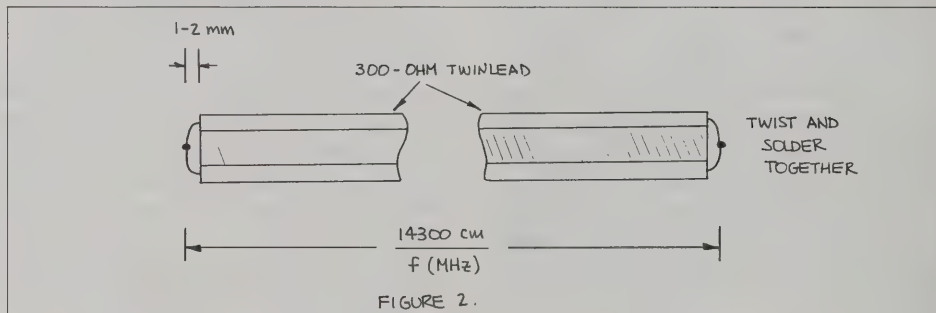


Fig 2: Construction of the folded dipole elements.

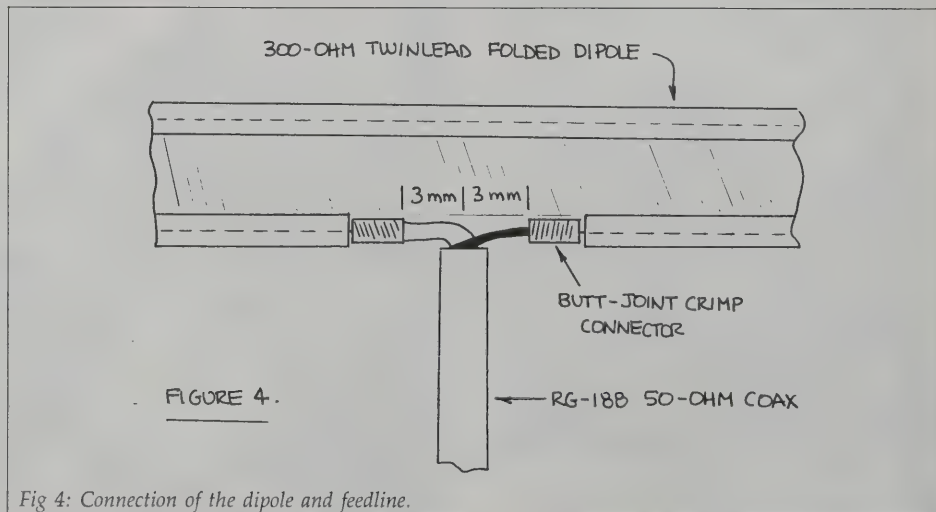
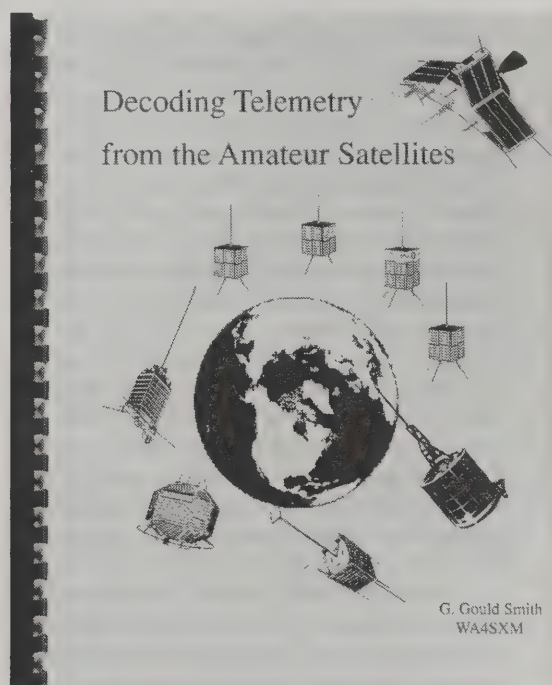


Fig 4: Connection of the dipole and feedline.

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will be glued to the open ends of the PVC tubing elements. The four pieces of threaded PVC pipe can be made from two pieces of 8-inch long PVC pipe threaded on both ends. After cutting to length, the unthreaded (cut) end of the PVC pipe should be glued to a T-connector, and the other end screwed into the aluminum box and tilted to 30° for lefthand or righthand polarization. Epoxy on the PVC pipe threads inside the aluminum box can be used to hold the elements at a 30° tilt; do not epoxy them until the correct tilt angle has been established.

Insert the unconnected end of an RG-188 coaxial line transformer partially into one side of a PVC T-connector and then into the PVC pipe connecting it to the aluminum box. At this point you should note that you must ensure RF current symmetry in the elements by assembling each so that the end of the dipole connected to the center conductor of the RG-188 emerges on the same side of each PVC T-connector. A dab of red nail polish on the end of each

dipole connected to the center conductor will remind you of the need for symmetry and allow quick identification after the dipoles have been constructed and taped. After each dipole and coax line has been inserted into the PVC T-connector, with the ends of the dipole emerging from each side of the 'T', insert but *do not glue* PVC tubing sections over over the dipoles and into the T-connector. You may want to trim the elements to a higher frequency or completely rebuild the dipoles and phasing lines (How can I rebuild thee? Let me count the ways!). The PVC tubing sections should be cut to equal lengths and just long enough so that the tips of the dipoles do not stick out.

In a symmetric pattern, bring the ends of the RG-188 coaxial lines to a point above the center of the aluminum box and twist the center conductors together. I used plastic cable ties to hold the four coax lines symmetrically together. Cut a 10-12 cm length of #16 or #18 tinned bus wire, wrap one end three or four times around the RG-188 cable bundle where the braid has been exposed, trim and solder well to each of the braids. (The magic of teflon cable will be revealed to you.)

Now, cut and solder the twisted RG-188 center conductors to the N(f) connector center pin. Cut the tinned ground lead (attached to the RG-188 braid) to about 4 cm and tack-solder it to the ground lug. The length of this lead is used to adjust the SWR at the operating frequency, so do not cut it too short to begin with!

Find the frequency at which the SWR is a minimum; at this point, it will probably be below the design frequency. Shorten the ground lead by 1 cm and remeasure. Remember that the aluminum box cover will also have some effect on SWR. In this way, adjust the length of the ground lead for minimum SWR at the operating frequency with the aluminum cover in place.

Finally, glue the eight PVC tubing sections to the T-connectors and eight PVC endcaps to the ends of the tubing sections. Fig 5 shows the completed antenna. Voila, un Lindenblad! ■

References:

1. M. R. Davidoff, *The Satellite Experimenter's Handbook*, second edition, (Newington: ARRL, 1990).
2. H. Sodja, "Lindenblad Antennas for Microsat Omnidirectional Reception", *The AMSAT Journal*, July 1990, p 4.
3. H. Sodja and S. Mitchell, private communication, 14 April 1991.
4. *The ARRL Antenna Book*, 15th edition, Chapter 20, "Spacecraft Antennas", (Newington: ARRL), 1988.
5. W. N. Caron, *Antenna Impedance Matching*, (Newington: ARRL), 1989.

Ron Ott, W6XY is a physicist at the University of California Lawrence Livermore National Laboratory. He was first licensed in 1958 as WV6FAD and then later as KIYXZ in Connecticut. The callsign W6XY was first assigned to Reg Tibetts, W6ITH, as one of the many "experimental" callsigns used for portable communications during the construction of the San Francisco Bay Bridge. His current interest in Amateur Radio centers around the OSCAR satellites although he is also interested in "signal Sleuthing" of other satellites.

Editor's Historical Note

By Ron Long, W8GUS:

In this issue we present two articles on the Lindenblad antenna. This antenna was brought to the attention of radio amateur satellite enthusiasts by Martin Davidoff in the *Satellite Experimenter's Handbook*, Volumes I and II. The antenna was invented by Nils E. Lindenblad, an employee of the Radio Corporation of America laboratories at Rocky Point New York. He applied for a patent on August 12, 1938 and on October 15, 1940 U. S. Patent #2,217,911 was issued in his name and assigned to RCA. Lindenblad mentioned the antenna in a brief article in *Communications*¹ but the most frequently quoted reference is to an article by Brown and Woodward². They worked at the RCA Research Laboratories in Princeton, New Jersey where Dr. Brown was a vice president and Mr. Woodward was a staff member of the antenna group. Their article describes the theory of the antenna in some detail and includes a description of the model antenna with measurements of circularity and the technique used for impedance matching. Their Lindenblad design is frequently seen around FAA control towers. Editing these articles brought back fond memories for your editor since he had the pleasure of working for Dr. Brown and Mr. Woodward at RCA Laboratories in 1955. ■

References:

1. N. E. Lindenblad, "Antennas and Transmission Lines at the Empire State Television Station," *Communications*, April 1941, Vol 21, No 4, p 13-14.
2. George H. Brown and Oakley M. Woodward, Jr., "Circularly-Polarized Omnidirectional Antenna," *RCA Review*, June 1947, Vol 8, p 259-269.

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My July 1990 *AMSAT Journal* article, "Lindenblad Antennas for Microsat Omnidirectional Reception" ¹ was based on the Lindenblad antenna design as described in the *Satellite Experimenter's Handbook* ² which assumes that the feedpoint impedance of a folded dipole is $300 + j0$ ohms. Each of the four dipoles is then connected to the antenna feedpoint by a half wavelength of 300 ohm twinlead. The four transmission lines are connected in parallel which should give 75 ohms. A connection to 50 ohm coax is shown with the remark that an additional matching section in the form of a 75 to 50 ohm coax matching section could be used if desired. The problem with this is that dimensional inaccuracies (especially at 435 MHz) and other aspects of folded dipole construction can result in a feedpoint impedance quite far from the usually quoted $300 + j0$ ohms. Transmission line velocity factors and dimensional inaccuracies in the matching sections can also drastically affect the impedance at the point of parallel connection. Finally I made an error in my calculation of the coax quarter wave matching transformer. To match 75 ohms to 52 ohms should require a transformer made of 62 ohm coax rather than 93 ohm as specified in my article. However when I constructed the antenna as shown in the article I got a good match (1.1:1). Since I got the SWR I expected I never checked the calculations. Much comment has been made about the wrong quarter wave transformer impedance but in fact the real lesson as this article will demonstrate is that, especially at 435 MHz, it is very difficult to match theoretical calculations with measurements in the real world.

Stu, WD4ECK/7 undertook an in-depth theoretical investigation of the apparent anomaly with MININEC ³, a powerful antenna analysis program. His calculations disclosed that the close overlapping spacing added an inductive component to each folded dipole's feedpoint Z, raising mine from the expected 300 ohms to $573.5 + j431.1$. When fed through my phasing lines this unexpectedly high Z was transformed by my too high 93 ohm matching section, giving the observed low SWR. Stu's calculations revealed that the mismatched reactive component in my

"serendipity" match gives me a low SWR at the expense of storing some power in the near field of my antenna ⁴.

To obtain a non-reactive feedpoint impedance, the Lindenblad's folded dipoles must be shortened from their "free space" resonant lengths. These shortened dimensions are a complex function of the folded dipole's wire diameter and length to spacing ratio. This relationship could not be reduced to a simple formula. Using MININEC, Stu constructed Tables 1 and 2 which give the dimensions and resulting impedances for folded dipoles in the Lindenblad configuration for the 2 m and 70 cm satellite bands.

Stu then tested theory by building a MININEC-modeled 70 cm Lindenblad which performed as predicted. I then built a LHCP and RHCP 2 meter MININEC-modeled pair of Lindenblads and likewise confirmed his findings. My SWR for both antennas is 1.35:1. A quarter wave coax balun ⁵, tuned with a dip meter and spaced 7/8 inch from the coax feedline, connects the balanced phasing lines to my coax. Without the balun my SWR was almost 1.5 to 1.

Theory vs. Reality

Before going further perhaps it should be pointed out that in commercial practice a transmitting antenna is considered satisfactory if the SWR is less than 2:1. A receiving antenna can have an SWR of 3:1 or higher and still perform adequately. Furthermore, in the real world, matching sections are frequently "pruned" from theoretical lengths in order to achieve a final match. With this in mind, all of our Lindenblad models (including the one in

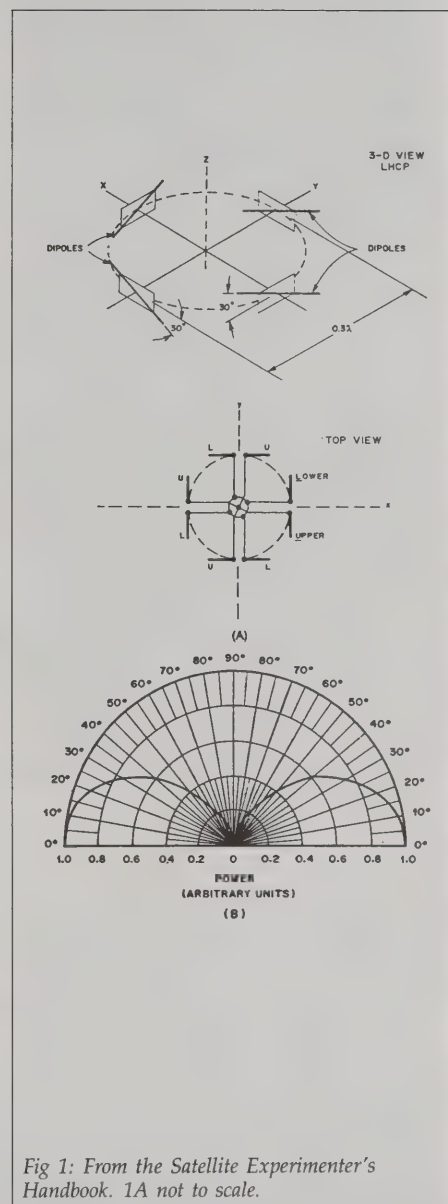


Fig 1: From the *Satellite Experimenter's Handbook*. 1A not to scale.

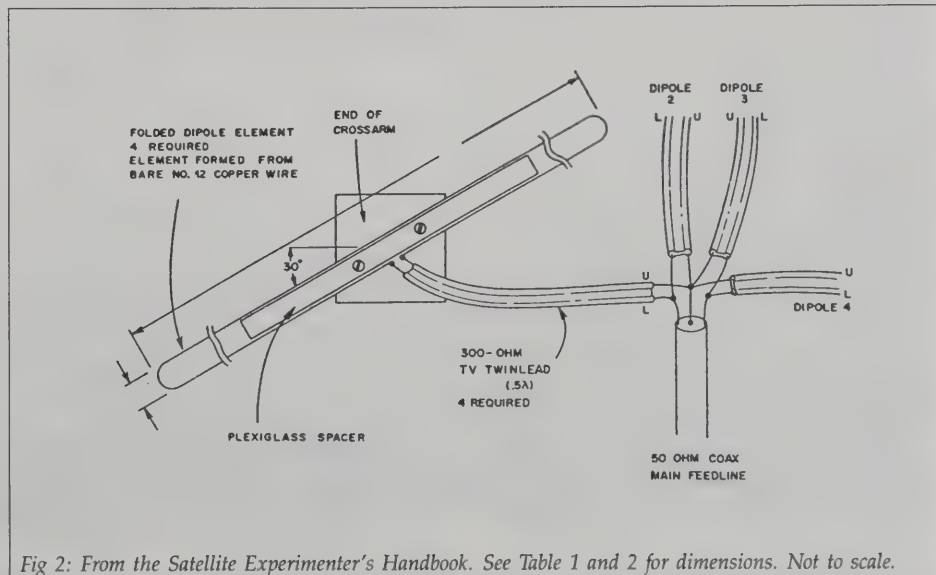


Fig 2: From the *Satellite Experimenter's Handbook*. See Table 1 and 2 for dimensions. Not to scale.

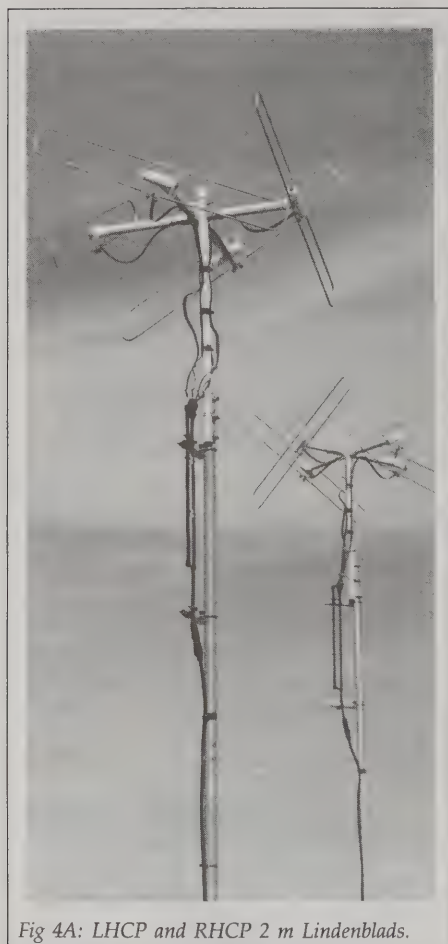


Fig 4A: LHCP and RHCP 2 m Lindenblads.

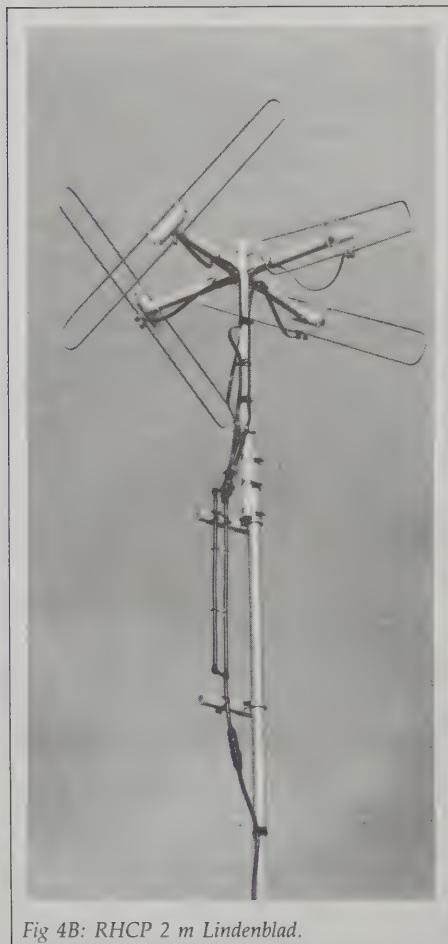


Fig 4B: RHCP 2 m Lindenblad.

my original article) have turned out very well. However, being hobbyists with time to spare we continued our efforts to produce an antenna with 1:1 SWR.

Experimenting with various MININEC configurations Stu decided to attempt to build a Lindenblad with a 1:1 SWR. MININEC indicated he'd have a 200 ohm feedpoint impedance with folded dipoles 29.5 cm long with a 1/4 inch diameter lower element and #14 wire upper element spaced 1.3 cm. This would result in a perfect 50 ohm match after the parallel phasing lines divided this by four.

Stu's 200 ohm "Lindy" had a 1.3:1 SWR at the design frequency. About this time Ron, W6XY, joined our efforts to build the perfect Lindenblad, but using a different approach ⁶. He too found the 1:1 SWR elusive (see accompanying article: Ed). As we experimented and tested various Lindenblad configurations several points became clear.

As we suspected, my suggestion in the July 1990 *AMSAT Journal* to experiment with the routing of the phasing lines until you got the lowest SWR was in effect changing the electrical length of the phasing lines, which changed the impedance seen by the 50 ohm coax feedline. Some builders reported needing to slightly trim their phasing lines to get their SWR below 1.5:1.

Stu and Ron tried using coax phasing lines to avoid this suspected twinlead field interaction problem. Stu used a coax sleeve balun at each element feedpoint and Ron did not. But that 1:1 SWR still eluded us. Tests revealed that at 437 Mhz a one millimeter change in length of the 50 ohm coax phasing lines made a noticeable difference, more so than with 300 ohm twinlead phasing lines.

Around this time *QST* published an ar-

ticle explaining some of MININEC's limitations ⁷. Stu also established contact with a professional antenna design firm that uses MININEC. He learned that even the professionals must trim and fine tune their MININEC-modeled antennas to account for "real world" factors. Stu and Ron were actually within the "real world" range to be expected. Stu found his resonant frequencies to be consistently 1 to 2 percent higher than expected, while Ron found his to be lower by the same amount, using different construction materials and designs.

Some of the variables that were found to affect impedance that are not accounted for by MININEC are: 1) stray capacitance at the feed points, 2) the true angle of the elements (a couple degrees off of 30 degrees makes a difference), 3) an unpredictable folded dipole end effect because of the element's end shape and coupling to other elements, and 4) proximity of other near field objects such as the phasing lines and baluns. There are probably more.

Real World Performance

Our struggle for the golden 1:1 SWR was more because of our trying to be design purists and to validate MININEC rather than from need. The SWR that builders are reporting is operationally insignificant as even a 1.5:1 SWR only results in a 5 percent (0.2 dB) power loss in a lossless line ⁸. With the low loss lines we run to our satellite antennas, your SWR signal loss should be under 1 dB (less than the human ear can perceive). A bit of fussing with the phasing line routing and maybe their lengths should reward you with an SWR below 1.5:1.

Reports from other satisfied Lindenblad builders confirms this. Everyone agrees that for microsat use the



Fig 3: Lindenblads on top of a Federal Aviation Agency Airport Control Tower in Merced California.

Lindenblads outperform linear polarized omni antennas. Several builders report good performance without baluns, which simplifies construction. Except for the SWR improvement mentioned previously, I could not detect any operational improvement when I added baluns. Of course, "theory" says you should use a balun to feed a balanced load to coax.

The Microsats' downlink is RHCP when using normal PSK and LHCP when using raised cosine. This is because the turnstile phasing lines at the satellite are changed when different transponders are used. But when there is deep QSB caused by satellite orientation and other factors you must in practice switch polarization to bring the signal back up to levels necessary in order to maintain a solid connection. Therefore it is essential that you have two Lindenblads (one RHCP and one LHCP) and be able to switch between them during a pass.

I also use a pair of 2 meter Lindenblads for the uplink and find that they outperform my linear (groundplane) antenna. I determine which uplink polarization to use by observing if the byte count which PG displays increases with each transmit burst.

Construction Ideas

Figs 1A and 2 show schematics (not to scale) of the Lindenblad's layout. In the July *AMSAT Journal* article ¹ I described my 70 cm Lindenblads that were built from scrap plexiglass. Use the dimensions in Table 2 and not the ones in the original article.

The accompanying article in this issue by W6XY describes another construction technique using an outdoor electrical utility box for the center hub, with coax phasing lines placed inside four 1/2 inch PVC pipe

TABLE 1

146 MHz. Lindenblad Antenna Characteristics: Dimensions given in cm, impedances in ohms.

Spacing	#12 Wire		1/4 inch dia.	
	Length	Impedance	Length	Impedance
4	87.3	299.3	84.9	288.1
5	86.4	296.3	84.1	284.8
6	85.6	293.5	83.3	281.5
7	84.7	289.9	82.5	278.0
8	83.8	286.0	81.5	273.3
9	82.9	281.9	80.5	268.4
10	82.0	277.5	78.8	265.0
15	77.2	251.5	74.8	238.5
20	71.8	219.8	69.2	207.7

Phasing line twinlead length 84.2 cm (0.82 λ)
0.3 λ element spacing (61.6 cm)

TABLE 2

437 MHz. Lindenblad Antenna Characteristics: Dimensions given in cm, impedances in ohms.

Spacing	#12 Wire		1/4 inch dia.	
	Length	Impedance	Length	Impedance
2	27.9	282.4	26.7	264.0
3	27.0	269.3		
4	26.0	252.8	24.9	231.9
5	25.0	235.4		
6	24.0	217.7	22.7	193.5
7	22.7	195.8		

Phasing line twinlead length 28.1 cm (0.82 λ)
0.3 λ element spacing (20.6 cm)



Fig 6: 2 meter Lindenblad balun and phasing line attachment detail. The SWR will vary in windy conditions unless the lines are secured to spacers or the mast.

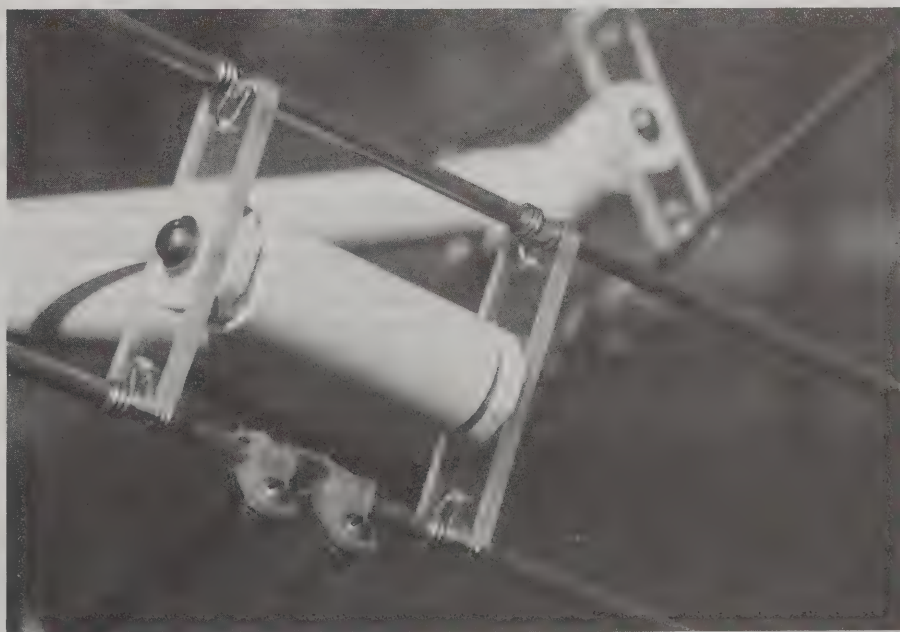


Fig 5: PVC "T" fittings with flat plugs provide a surface for bolting the plastic spacers. Elements are attached to the spacers with heavy gauge wire.

booms which support the folded dipoles. Folded dipoles made from TV twinlead are sealed inside PVC pipes and attached to the ends of the PVC booms with PVC "T" fittings. This gives a neat, rugged and weatherproof structure.

Fig 3 shows the approach used by the FAA's Lindenblads. These antennas follow the design in the original article by Brown and Woodward.⁹ This article contains a theoretical analysis supporting the 30 degree angle of the dipoles and a detailed description of the construction of the antennas and the matching scheme.

For my 2 meter uplink "Lindy" (Fig 4) I used 3/4 inch white PVC pipes reinforced with wood dowels bonded inside with PVC cement. This reinforcement is essential where you will be clamping or drilling. Use a length of dowel-reinforced PVC (or other non-conducting mast material) to support the "X" booms that go beyond the point where the phasing lines connect together to the coax. See Figs 5 and 6 for more details.

The polarization of a Lindenblad will be RHCP (clockwise) or LHCP (counter-clockwise) from the perspective of viewing the 30 degree slopes from the center of the base. Fig 1A is LHCP.

The dimensions of the power divider phasing twinlead lines in Tables 1 and 2 are calculated for ordinary 300 ohm TV twin lead with a 0.82 velocity factor. For transmission lines with a different velocity factor, adjust these lengths with the formula:

$$\frac{1}{2} \text{ wavelength (cm)} = \frac{14998.7 \times \text{velocity factor}}{\text{Freq. in MHz}}$$

As discussed above, if you use twinlead, experiment with the routing of your phasing lines until you get the lowest SWR, keeping all 4 lines as symmetrical and separated as much as is practical.

I have decided to stay with twinlead phasing lines as they are easy to build and easy to use for tuning. Also I wish to transmit as well as receive on my "Lindys". Cliff, W6HDO reported smoke coming from his RG-58/U coax sleeve balun when he fed 100 watts to it. Teflon type coax as used by W6XY should also solve this problem.

Besides using my Lindenblads on the Microsats, I find they do an excellent job on all the other LEO birds. As the word spreads, I believe the "Lindy" will eventually become the omni antenna of choice for serious satellite users. ■

References:

(1) Sodja H, W6SHP, "Lindenblad Antennas for Microsat Omnidirectional Reception", *AMSAT*

Journal, Volume 13, No. 3, July 1990; p 4-30

(2) Martin R. Davidoff, K2UBC, *The Satellite Experimenter's Handbook*, second edition (Newington: ARRL, 1990); also available from AMSAT, p 6-17 - 6-20.

(3) MININEC, by Brian Beezley, K6STI, 507½ Taylor St., Vista, Ca. 92084. MININEC Lindenblad modeling by Stu Mitchell, WD4ECK/7, 3030 El Dorado, Medford Or. 97504, USA.

(4) W. L. Stutzman, G. A. Thiele, *Antenna Theory and Design*, John Wiley & Sons, Inc., New York, 1981, p 47.

(5) *The ARRL Antenna Book*, 15th edition, p 26-9 - 26-10 (Newington: ARRL).

(6) Ott, R, W6XY, private communications, April through August, 1991.

(7) Lewallen, R, W7EL, "MININEC: The Other Edge of the Sword", *QST*, February 1991, p 18-22

(8) W. N. Caron, *Antenna Impedance Matching*, (Newington: ARRL), 1989; p 1-12 - 1-13.

(9) G. H. Brown and O. M. Woodward, Jr, "Circularly Polarized Omni-directional Antenna," *RCA Review*, Vol 8, June 1947, p 259-269.

Howard Sodja, W6SHP, professionally is a social worker. He was first licensed in 1955 and now holds an Extra class license. He first got interested in Amateur satellites in 1978 on AO-8. He enjoys experimenting with a variety of satellite related gear and antennas. He has been published in the *AMSAT Journal*, *AMSAT-UK's OSCAR News* and *QEX*. He has written telemetry decoding programs for AO-13 and FO-20 which are available from Project OSCAR.

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Automatic Updating of Keplerian Elements

By Roy Welch, W0SL
AMSAT-NA Software Manager

One of the features found in some of the satellite tracking software programs offered by AMSAT is the Automatic Updating of Keplerian Elements. For the purposes of brevity in this article I will generically call it the AutoUpdate feature. This feature can be found in programs such as the current versions of INSTANTTRACK, QUIKTRAK 4.0 and ORBITS II & ORBITS III. These programs will accept a text file of the Keplerian Elements, in either AMSAT or NASA Two Line format and update their satellite files with the latest numbers.

While there are those of us who are used to using computers daily to do a multiplicity of jobs, there are some newcomers to the satellite tracking business who have recently acquired their computers just to be able to track the birds. The general terminology and computerese has not yet become a second language to them. This article is for them.

The AutoUpdate features in the above programs, while they may differ a bit in operation, all have to follow the same

general steps to effect the update. First, there is a menu item displayed in the program that allows you to select a Keplerian Element update option. Once you have chosen this option, you are given further options to either update the numbers manually from the keyboard or to enter the AutoUpdate routine.

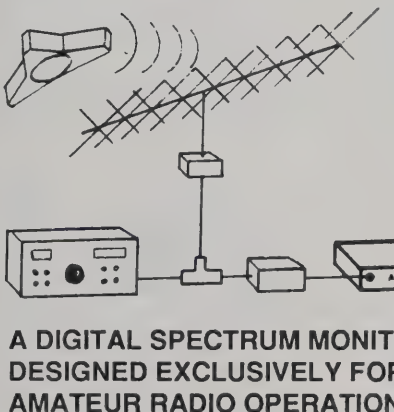
The procedures in the AutoUpdate routine are pretty straight forward if you follow the on screen prompts. First however, you have to know what the prompts are asking you to do, and that is where the problem seems to be with the majority of inquiries we have been receiving. The options usually offered by the programs are:

1. Do you want to AutoUpdate the elements?
2. In what format are the elements? AMSAT or NASA?
3. What is the file name of the file containing the elements?

Everybody seems to handle number one ok. Most seem to handle number two also. It is number three that causes the problem. What is this file? How do I know what its name is? Where does it come from?

The fact that the Keplerian elements are found on several bulletin boards such as the DRIG BBS (214-394-7438) and others is pretty well known. The elements are also available through Packet Radio Bulletin Boards and usually once a week from the Microsat bulletin boards. That's where I get my updates. Those who are having AutoUpdate problems have, almost without exception, been able to get a print out of the latest elements from one of these sources. The break down comes in not understanding how to automatically get what they see on the screen or printer, into the tracking programs.

When you log into some of the BBS sources containing the Keplerian Elements, you have to use some sort of communication software that allows you to communicate with the BBS. Usually, but not always, these communications programs have a feature called, for lack of a better name, a "Capture-To-Disk" capability. If your communications program doesn't have this, then stop reading now and go and buy one. You cannot use the AutoUpdate features on the tracking programs unless you can Capture-To-Disk.



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**Tom (W6ORG)
Maryann (WB6YSS)**

When you activate Capture-To-Disk in your communications program, it will ask you to choose a file name into which the captured text will be written. This file can be written to your hard drive or to any of your diskette drives depending on the file name given. If you want the data written to a diskette in floppy drive A, then specify the file name as A:KEPS.DAT for example. You can select any valid file name. Most communications programs have a default name that will be selected if you don't want to choose one. It will be something like ??????.LOG or ??????.RUN, for example. When Capture-To-Disk is activated, everything you see on the screen will also be copied to a diskette under the filename you have selected. Let's assume you selected KEPS.DAT.

When you log onto the BBS, do not activate the Capture-To-Disk feature until just before the Keplerian elements are to be received, if this is possible. The reason for doing this is that you will avoid having a lot of extra text in the captured file before the Keplerian element data that you want. The tracking program will read this text and try to make sense out of it. After some validity checks, the line of text will be discarded or you will be asked if you want to skip it. This can eat up a bit of your time as the tracking program chews on this stuff and stops for you to decide what to do. The

AMSAT format will generally not cause this because the program will sort through the data looking for key words or phrases such as "SATELLITE NAME:", etc.

If at all possible, *do not* edit the data to remove extra text, etc. Word processors have a nasty habit of inserting extra blanks to right justify text on the printed page and otherwise inserting non-displayed formatting characters. The NASA data format depends on each set of numbers being in *exactly* the right position from the beginning of the line. Having extra blanks inserted in a NASA format data line will absolutely get that line tossed out as a Checksum Error. Within limits, the AMSAT format can have extra blanks inserted and still pass the AMSAT checksum test. You cannot have extra blanks imbedded in the key words or the data itself, however. If you must edit, then use a text editor such as EDIT.COM that comes with DOS 5.0. Others will do as well. Don't call me if you do edit and have problems. I do not edit the data files. I just let the programs chew on the stuff. They should be good enough to handle the non-data junk.

Now suppose you have logged onto your friendly BBS, requested the Keplerian elements and captured the file to your the default drive in the C:COMM directory where your communications program is located. Also assume you chose the file

name KEPS.DAT to capture the Keplerian elements in AMSAT data format. This means that the complete file name for the captured data file is C:COMMKEPS.DAT. Write it down. Put it on a sticky note and stick it to the front of your monitor because you will need it. This is the name that you must enter from the keyboard when the tracking program asks for the name of the file containing the Keplerian elements.

Now load your tracking program and select the update routine from the menu. Select the AutoUpdate function and specify, for this example, the AMSAT format. Lastly, furnish C:COMMKEPS.DAT as the file name when requested and then watch the fun start. You will update the Keplerian elements for all the satellites in your files *in a few seconds*.

A few words concerning tracking program differences. Some programs will look at the data and if you currently do not have a particular satellite in your existing files, it will be created in the files for you. Others depend on the user manually entering at least the NASA catalog number since this the key on which the program decides what to update. Another lets you decide whether you want to just update what you already have, or take all satellites in the captured file.

I hope this helps to answer the questions out there. If it doesn't, let us know. If we don't what the questions are, we can't provide the answers. Sometimes even when I know the questions, I don't know the answers, but I can usually find someone who does. ■



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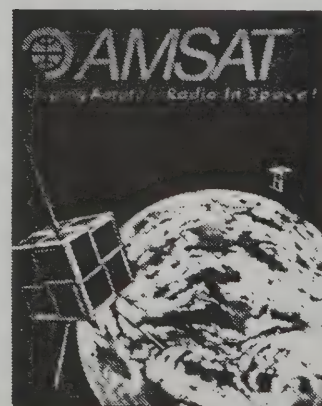
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Oscar Zero: An Introduction To EME For The Satellite Operator

By: Ray Soifer, W2RS

[The following is an edited version of a paper which I presented at the Sixth AMSAT-UK/University of Surrey Colloquium, Guildford, England, July 27, 1991. References unique to the U.K., and material which substantially duplicates that which appeared in my two recent articles in QST [1], have been deleted. The full original text appears in the Colloquium Proceedings, which are available from AMSAT-UK.]

Interest among Amateurs in utilizing the oldest, largest and most reliable communications satellite, the moon (familiarily known as "Oscar Zero"), has grown rapidly in recent years. If you are among the many satellite users who are intrigued by Oscar Zero but have not considered how close your own station may be to lunar capability, this paper is addressed to you.

Your Oscar Station

Let us consider how you, as the owner of a good, but by no means exceptional, Oscar 13-class satellite station, might join in. Inasmuch as my own experience with Oscar Zero has been concentrated at 2m, I shall focus on this band although bringing in relevant information about 70cm operation as required. In this discussion, let us assume that your present station includes good quality receiving systems for 2m and 70cm, up to 100 W output on each band and satellite-type antenna systems (i.e., circularly polarized with azimuth and elevation control) having forward gains of about 15 dBi at 2m (e.g., the KLM 2M-22C) and 17.5 dBi at 70cm (e.g., the KLM 435-40CX). Does that sound familiar? The maximum eirp capability of such a station at full power, which I hope you are not using on Oscar 13 under normal conditions, is about 3.2 kW (35 dBW) at 2m and 5.6 kW (37.5 dBW) at 70cm.

Lunar Propagation

Now let us consider the propagation path from Earth to Oscar Zero and back again ("Earth-Moon-Earth" or "EME"). When the moon is at perigee, it is approximately 221,000 miles (356,000 km) away. It is, of course, roughly spherical (very roughly) with a diameter of about 2,160 miles (3,480 km), subtending about 0.5 degrees of arc as seen from the Earth, but with a typical radio reflectivity at these frequencies of only about 6% - 7%. Under these conditions, the round-trip path loss is approximately 251.5 dB at 144 MHz and 261.0 dB at 432 MHz, about what your signal would have to overcome if someone were trying to receive it from a space probe located at the orbit of the planet Jupiter some 400 million miles distant. When the

moon is at apogee (253,000 miles or 407,000 km), the path loss is about 2 dB greater than this.

Calculating The S/N Ratio

Optimal receiving conditions occur when the moon appears against the quietest point in the cosmic noise map — the so-called 'cold sky' level. That does not occur very often but when it does, the sky noise heard by your receiver measures approximately 165 K at 144 MHz and 11 K at 432 MHz. If we assume that your receiving system has a system noise temperature of 80° K, a figure typical of a good GaAsFET preamp combined with low-loss feeder and a high-quality converter, the combined noise level in your receiver (in a bandwidth of 100 Hz) is about -154.7 dBm at 144 MHz and -159.1 dBm at 432 MHz. So, remembering to flip the polarity switch from one sense to the other during the 2.5-second transmission delay between transmitting and receiving, how close can you come to hearing your own lunar downlink?

If $(S/N) = P_t + G_t + G_r - L_p - P_n$, where

P_t = transmitted power (in this case 100 W or +50 dBm),

G_t = transmitting antenna gain (15 dBi at 144 MHz and 17.5 dBi at 432 MHz),

G_r = receiving antenna gain (in our example, the same as G_t),

L_p = path loss (251.5 dB at 144 MHz and 261.0 dB at 432 MHz), and

P_n = receiving noise power (-154.7 dBm at 144 MHz and -159.1 dBm at 432 MHz),

then I'm afraid the answer isn't very encouraging: according to the above equation, your received signal will be 16.8 dB below the noise level at 144 MHz and 16.9 dB below the noise at 432 MHz. However, as Tom Clark, W3IWI, would say, "But wait, there's more!"

System Degradation (DGRD)

To begin with, the reality is even worse than we have calculated. How often, after all, is the moon at perigee and at the point of lowest sky noise at the same time? Hardly

ever. Some years ago, Derwin King, W5LUU, came up with a handy definition of "system degradation" to take into account the moon's actual position relative to the earth and the background of cosmic noise; according to W5LUU's convention, system degradation (often referred to as DGRD in lunar tracking software) is the difference between the actual S/N ratio and the one that would prevail at perigee and a 'cold sky', assuming a receiver noise temperature of 80° K as we have done. The mean value of DGRD encountered during my own QSOs at 144 MHz was 2.4 dB; these same conditions would produce DGRD of about 1.2 dB at 432 MHz. DGRD, as we and W5LUU have defined it, subtracts directly from the S/N ratio, so to adjust our "optimal" predictions for more realistic conditions, we must increase the signal deficit to 19.2 dB at 144 MHz and 18.1 dB at 432 MHz. Not a very good start, is it?

Signal Processors: Digital, Analog and Human

There is indeed more, and some of it was provided by Tom Clark himself who, with Bob McGwier, N4HY, and several others, actually detected their own lunar echoes at 70cm using just such a station as I have described and digital signal processing (DSP) to narrow the receiving bandwidth mathematically. For example, if the effective noise bandwidth is reduced to 1 Hz through a computerized Fourier transform, the 432 MHz S/N ratio would turn out to be 1.9 dB instead of -18.1 dB. Now, that's progress! However, most of us want to pass more information than a steady carrier, and transmitting CW via the moon at 15 WPM requires a bandwidth of 60-100 Hz depending upon the fading characteristics of the path. So, for the kind of communication presently utilized by most amateurs, we've got to rely on the signal processors contained between our ears. Fortunately, however, they still work pretty well.

Ground Station Requirements

One of the wonderful things about Oscar Zero is that you really do not have to hear your own downlink signal in order to make two-way contacts. If the station at the other end has a larger antenna and more power than you have, all that really matters (most of the time) is that he hear you. After all, I do hope you already know what you're sending! So then, what kind of receiving station would it take to hear your signal via the moon?

432 MHz

Consider for a moment the 70cm example. If we are to make up a deficit of 18.1 dB, we would have to increase the receiving antenna gain by the same amount, from 17.5 dBi to 35.6 dBi. That would be the equivalent

of replacing the Oscar cross-Yagi with a 60-foot dish! Under optimal conditions rather than the typical DGRD value of 1.2 dB, the dish requirement would be lowered to 50 feet; not much help there. However, if instead of 20 dBW your power level can be increased to 26 dBW, the receiving antenna requirement would diminish from 35.6 to 29.6 dBi. That corresponds only to a dish of 30 feet (9m) diameter, and there are actually several of those in everyday use on 70cm EME. So, under normal conditions, an Oscar 13-type station can make at least some two-way contacts via Oscar Zero on 70cm if the power output is raised from 100 W to the 300-400 W level.

Alternatively, one can also leave the power level at 100 W and increase the size of the antennas. If the length of the Yagis is doubled to 13 wavelengths (about 30 ft or 9m), two of those would produce sufficient gain to result in QSOs with 9m dish stations. Or, four of the 6.5-wavelength Oscar antennas would produce roughly an equivalent result. How about 200 watts and two Oscar antennas? The same thing. The standard Oscar station which we have postulated is only about 5-6 dB away from meaningful EME capability at 70cm, at least to be able to work the larger stations, and as we have seen, there are innumerable practical ways of achieving that 5-6 dB improvement in performance.

144 MHz

The situation is even better at 2m but will take a little ingenuity. Referring to the signal deficit of 19.2 dB which we calculated earlier (for DGRD = 2.4 dB), a receiving array large enough to hear your Oscar station would have to have forward gain of 34.2 dBi, which is only 0.9 dB more than the 48-Yagi array of W5UN in Marvel, Texas. Can Dave Blaschke's (W5UN) ears pick out a signal 0.9 dB below the noise in a 100 Hz bandwidth? Perhaps, but if the system degradation is reduced to 1.5 dB (a value that occurs not too infrequently in practice) the S/N deficit would be eliminated entirely. Under conditions which are better than average but not at all improbable, then, our figures show that W5UN might well be able to hear your Oscar 13 sta-

tion "as is." Well, not quite "as is": EME antennas for 144 MHz are all linearly polarized, generally horizontal except for a few with Z-axis rotation capability. In order to avoid the 3 dB mismatch between linear and circular arrays, you will have to disconnect the vertical elements from the feeder and feed the horizontal elements alone.

Ground Reflection Gain

Now for some of that ingenuity: One advantage of 2m over 70cm for the small EME station is that the typical levels of sky noise encountered at 144 MHz are not far removed from the 290° K 'black body' radiation picked up from the earth itself when the antenna is pointed at the horizon rather than up into the sky; contrast that with the typical sky noise figures of 20 K or less experienced at 70cm. At both frequencies, pointing the antenna at the horizon generally results in enhancement of the transmitted signal through ground-reflection gain of 3-5 dB; at 2m, the price paid for this in receiving capability is often little to nonexistent, particularly for those living in quiet locations or operating at times when man-made noise is not likely to be prevalent.

Gary Kohtala, WA7NTE, operating as HL9TG with the U.S. Army in Korea, put together a simple station running 80 W to a single 4.2-wavelength Yagi (35.4 dBW eirp, about the same as our Oscar station) and worked not only W5UN but also KB8RQ, VE7BQH and N5BLZ. Can an Oscar-class station work EME? With horizontal polarity and ground-reflection gain, most certainly yes!

So far, my own Oscar Zero QSO count on 144 MHz with 150 W and the single 3.2-wavelength Yagi (37 dBW) is in excess of 50 with 19 different stations using 24 different antenna systems, including not only "superstations" such as W5UN with 48 5-wavelength Yagis, but three stations in the four-Yagi class, two with six and six with eight Yagis or the equivalent (See Table 1).

Going Me One Better (Or More)

If you increase the power of your Oscar station from 100 W to 200 W, or add a second Yagi, you'll have more eirp than I do! A sta-

tion which uses 400 W to four 4.8-wavelength Yagis (e.g., K6MYC's popular 2M-5WL) would produce approximately 48.2 dBW eirp; 2m EME stations with eirp in this range, e.g., OZ1HNE, EA3DXU and WD5AGO, have worked more than 100 different stations via Oscar Zero. With 1.5 kW output to the same four Yagis, W7HAH has worked more than 400.

For those with eirp of 40 dBW or more, the greatly increased flexibility to be gained with elevation control would be well worth while, not only to reduce man-made noise but also to take advantage of times when the sky noise is well below 290° K. On the other hand, ground-reflection gain generally disappears at antenna elevation angles above 12 degrees or so. For the low-power station, the 3-5 dB of additional signal strength it affords often means the difference between success and failure.

Mutual Horizon Gain

We're not quite through with the ingenuity which makes 144 MHz such an interesting band for EME. Remembering that at 2m, ground-reflection gain may often be had with little or no penalty in terms of receiving noise, the path geometry sometimes can be chosen so that ground-reflection gain is available at both stations simultaneously. Instead of 5 dB, the total enhancement from this source can thus approach 10 dB. Because both stations in such a schedule will be picking up "black body" radiation from the Earth, it is often advantageous to schedule mutual horizon gain contacts when the moon will be at or close to perigee, to minimize path loss, even though the predicted sky noise may be at or even somewhat above 290° K.

Libration Effects

As discussed in QST¹, lunar libration gives rise to a quasi-random fading effect on reflected signals. Given the statistical fading distribution, it has been calculated that this libration fading can add 4.5 dB to reflected signal levels 10% of the time and 7.0 dB 1% of the time. The duration of these signal enhancements is inversely proportional to frequency. At 70cm they typically last less than one second, rendering them relatively useless for practical communication at the narrow bandwidths commonly employed in amateur EME. However, at 2m, libration peaks often last as long as 3-4 seconds, making them extremely useful when CW sending speeds of 15-20 WPM are employed.

Hearing My Own Downlink

With my station of 37 dBW eirp, the theoretical S/N ratio for hearing my own lunar echoes is approximately -17.4 dB; I went nearly five years without once hearing my own downlink through Oscar Zero. However,



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making use of mutual horizon gain (when listening for one's own downlink, the horizon gain is always mutual!) and libration enhancement at times of lunar perigee, this deficit has been overcome for brief bursts of signal; the preceding discussion illustrates how this was done.

Doppler Effects

Although the moon's motion relative to the Earth is relatively slow, EME signals do experience significant Doppler shift; the main contributor to this is actually the Earth's rotation on its axis. For the maximum case, i.e., a station on the equator when the moon is due east or due west at the horizon, the Doppler shift would be about 460 Hz at 2m and 1.4 kHz at 70cm; the return signal would appear higher in frequency than nominal by that amount with the moon to the east and lower by that amount with the moon to the west. The actual Doppler shift encountered in practice is generally less, depending upon the actual geometry involved; values of 200-300 Hz are common at 2m in typical situations at temperate latitudes when the moon is near the horizon at one of the two stations involved.

Lunar Tracking Aids

As with man-made Oscars, it is necessary to track Oscar Zero in order to point antennas properly; the large arrays often employed in EME work, and the weak signals, require more precise tracking than is often the case with artificial satellites. Man has been tracking the moon for thousands of years, certainly long before the invention of the computer. In the early days of EME, the 1960s and 1970s, amateurs often used nautical almanacs to aim their antennas. Even today, telescopes and optical boresights are commonly used, albeit more often in Arizona than in England. However, just as with RS-12 and Oscar 13, the use of a computer makes EME far easier and more enjoyable.

Many of the modern satellite-tracking programs, such as QUIKTRAK, SATSCAN and INSTANTRACK, will track the moon with accuracy sufficient for a single-Yagi station. However, they lack features important for arranging schedules such as a built-in sky noise map for calculating system degradation (DGRD). For all but the most casual applications, I strongly advise the use of a good special-purpose EME program. By far the best of the current EME programs, for those with the hardware to run it (EGA or VGA plus a hard disk), is W5UN's own Skymoon, available for a modest fee from Dave at the address listed below ². In addition to the features of the other programs mentioned, Skymoon incorporates the entire current 144 MHz EME Directory of active stations so that mutual windows may be determined easily.

The Directory itself, containing well over 1,000 detailed entries, is updated continuously and may be obtained in various forms (machine-readable as well as hard copy) from Bev Cavender, W4ZD ³. Also strongly recommended are the monthly *2-Meter EME News* published by K0IFL ⁴, the *U.K. newsletter 2M Direct* from G4PCS ⁵, or for 70cm operators, the *432-and-Above EME Newsletter* edited by K2UYH ⁶.

Finding Stations To Work

Now that you have assembled a station and know where to find the moon, what do you do now? Most current EME activity takes place by prearranged schedules; virtually all the operators mentioned in the newsletters would be happy to arrange a schedule with you. EME operators, after all, are in a friendly competition to see how many stations they

can work. As a 'new boy' (or girl), you'll soon find yourself popular indeed! During almost any weekend with favorable EME conditions, you are likely to find several of the larger stations calling CQ on their preassigned frequencies near the low end of the 2m band. W5UN, for example, may be found on 144.008 MHz while KB8RQ is at 144.016. Most of the more active stations have their "own" schedule frequencies; mine is currently 144.036 and if you really hear me, call me collect!

There are approximately three times as many active EME stations on 144 as on 432 MHz, no doubt because of the wide availability of suitable equipment. W5UN has worked over 1,400 of them. Among those currently active are 24- and 16-Yagi "super-stations" such as KB8RQ, SM5FRH, DL8DAT and W4ZD with 28-30 dBi forward gain, which have little difficulty working those with 100-150W and a single Yagi.

TABLE 1

W2RS
144 MHz EME
Stations Worked and Their Antennas Employed ¹

Station	Array ²	Gain (dBi)	Notes
W5UN	48x 4.8 WL	33.3	Worked with 50W CW
W5UN	48x 4.7 WL	32.5	Worked with 150W SSB & 50W CW
W5UN	32x 4.7 WL	30.4	Worked with 130W CW
SM5FRH	24x 5.2 WL	29.7	
KB8RQ	24x 4.8 WL	29.5	
KB8RQ	32x 3.2 WL	29.3	Worked with 130W CW
KB8RQ	16x 4.8 WL	27.8	
W4ZD	16x 4.8 WL	27.8	Mutual horizon gain
K1WHS	24x 2.2 WL	27.0	Mutual horizon gain
N5BLZ	12x 4.7 WL	26.7	
SM7BAE	16x 3.1 WL	26.3	Worked with 130W CW
DL8DAT	16x 2.8 WL	26.0	
AF9Y	6x 6.2 WL	25.4	
HB9CRQ	8x 4.8 WL	25.0	
I2FAK	8x 4.7 WL	25.0	
N1BUG	24x 4el Quad	25.0	Mutual horizon gain
VE7BQH	336el Coll	25.7	
VE7BQH	224el Coll	24.2	Worked with 130W CW
G8MBI	224el Coll	24.2	
OK1MS	8x 3.6 WL	24.1	
SM2CEW	6x 4.2 WL	23.6	Mutual horizon gain
K2GAL	4x 6.2 WL	23.3	Mutual horizon gain
KI3W	4x 4.2 WL	21.9	Mutual horizon gain
WB2JHG	8x 1.5 WL	21.6	Mutual horizon gain

Mean conditions prevailing:

Sky noise 275° K
Path loss over perigee 0.9 dB
System degradation ³ 2.4 dB

Notes:

- (1) Except as noted, W2RS output power is 150W CW to a single 3.2 WL Yagi. EIRP = 5 kW (37 dBW).
- (2) Except as noted, all antenna systems are multi-Yagi arrays where n WL is the length of each Yagi in wavelengths.
- (3) System degradation, as defined by W5LUU, is the overall S/N degradation with respect to ideal conditions (perigee and sky noise of 165 K) assuming a receiving system noise temperature of 80 K.

Schedules are often arranged, and frequencies assigned, via the EME Nets which meet weekends on 14.345 MHz; the net control stations of the 2m EME net currently employ on-line scheduling software and telephone modems to "pass the book" among themselves. This frequency is also used as a meeting place for EME and VHF-oriented operators at times when the nets are not in session. Many 70cm EME operators use Oscar 13 for this purpose as well; the 2m EME group is less commonly observed on AO-13 (although certainly welcome) as many of them do not have 70cm capability!

Owing to the weak signals involved, more than 99% of all current EME activity utilizes CW rather than SSB. The latter is sometimes used by the larger stations; 144.155 MHz is the usual SSB gathering place.

Operational Procedure

On-the-air procedure differs somewhat between 2m and 70cm. At 2m, schedules are typically half an hour in length (I normally run mine for one hour) and divided into two-minute segments (not 2-1/2 minutes as at 70cm). There is nothing sacred, of course, about two-minute segments; I have found, for example, that mutual horizon gain schedules work best if each station transmits for one minute in turn, and W5UN prefers one-minute segments for his random CQ activi-

First 90 Seconds

G3IOR DE W2RS G3IOR DE W2RS G3IOR DE W2RS G3IOR DE W2RS K
W2RS DE G3IOR W2RS DE G3IOR W2RS DE G3IOR W2RS DE G3IOR K
G3IOR DE W2RS G3IOR DE W2RS G3IOR DE W2RS O O O O O O O K
RO RO RO RO RO RO RO RO RO RO RO RO RO RO RO DE G3IOR K
R R R R R R R R R R R R R R R R R R R R R DE W2RS K
73 73 73 73 73 73 73 73 73 73 73 73 73 DE G3IOR AR

Final 30 Seconds

ty. In the absence of agreement to the contrary, however, two-minute segments are normally assumed.

Also by convention, the easternmost station transmits during the first segment of each hour, then the third, etc. Unlike 70cm, the T-M-O-5 system of signal reports has fallen into disuse at 2m. In 2m procedure, the only signal report sent is the letter O, and that only after both call signs have been received satisfactorily. Receipt of the O report is acknowledged with the letter R for "roger." A typical 2m EME QSO would go something like this, segment by segment:

In this example, I began sending O reports in the final 30 seconds of each segment as soon as I heard Pat's and my call signs from him. The RO from G3IOR signifies that he has heard my O as well as both call

signs from me and is giving me a report of O in return; had he not heard my O, but just the call signs, then he would send call signs in the first 90 seconds and O in the final 30 seconds, until he hears my O or I hear his. Assuming that he hears my O first, then he would switch to the RO sequence indicated. When I hear his RO, I switch to sending "rogers" (R). The 2m contact is considered to be complete at the moment G3IOR hears my R, since I would not have been sending that had I not heard his RO. Thus, both stations have gotten call signs, reports and rogers; the sending of '73' is a nice touch but is actually superfluous.

It's Your Turn

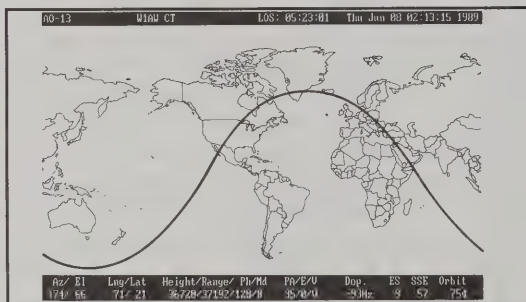
I hope you will consider giving Oscar Zero a try. After all, this is one satellite that is incapable of being overloaded and actually encourages high levels of eirp. As I have hopefully demonstrated, however, high eirp is not at all necessary if the proper techniques are employed. As Pat Gowen, G3IOR, has remarked, EME is the ultimate operating challenge; if you haven't yet tried it, the moon awaits!■

References:

1. R. Soifer, W2RS, "QRP EME at 144 MHz," *QST*, February 1989, and "More QRP EME at 144 MHz," *QST*, October 1990.
2. D.R. Blaschke, W5UN, 9102 Kings Drive, Manvel, Texas 77578, USA.
3. B.B. Cavender, W4ZD, P.O. Box 1083, Lake Placid, Florida 33852, USA.
4. J.M. Carter, K0IFL, P.O. Box 554, Union, Missouri 63084, USA.
5. M.H. Turner, G4PCS, 35 Culverhouse Rd., Luton, Beds LU3 1PY, England.
6. A. Katz, K2UYH, 1621 Old Trenton Road, RFD 4, Trenton, New Jersey 08691, USA.

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Line representation of QuikTrak 4.0 World Map

QuikTrak 4.0

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InstantTrack 1.0

For those concerned with greater speed and capability, InstantTrack offers all of QuikTrak's features plus instant visibility for your "favorite" satellites before you issue the first keystroke. More than 200 satellites and 1754 cities are on the menu and will be in full-color high-resolution EGA or VGA modes. *Hardware requirements:* IBM PC, AT, PS/2 or clone with at least 512K memory. EGA or VGA graphics required. Numeric coprocessor not required but recommended. Mouse not required but can be used on the map screens.

These are only a few of the features of QuikTrak and InstantTrack. The figures below reflect suggested donations to defray production expenses and benefit AMSAT's non-profit, educational activities.

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By Roy Welch, W0SL

AMSAT-NA Software Manager.

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Satellite Tracking Software and Computer for Less than \$100

By: William K. Nelson, N2GGQ

As incredible as it may sound, you don't have to spend \$1,500 for an MS-DOS machine to obtain satellite orbital predictions. It is quite possible to have your own computer and satellite tracking software for less than a hundred dollars. How is that possible? The answer is a Radio Shack TRS-80 Model 4 or 4p running QUIKTRAK, a satellite tracking program available from AMSAT. The software is approximately \$30 and the Model 4/4p can be found at hamfests or through the want ads in your local newspaper. I have a Model 4p that I purchased new in 1984 and a Model 4 that I recently purchased for \$40.

More about the hardware later. Let's take a look at QUIKTRAK, an AMSAT program for predicting the orbit of up to 14 user selected satellites. The program was written by Bob McGwier, N4HY and runs with TRSDOS 6.X or LSDOS 6.3 disk operating system. The program and ancillary files are furnished on a data disk without system files. Thus, a Model 4/4p with 2 disk drives is suggested. However, with thoughtful deletion of a few system files, it's possible to squeeze the tracking program on to a system disk. The program would then run on a Model 4/4p with one disk drive. (a Model 4p has 2 drives)

QUIKTRAK for the Model 4/4p is a tidy little program that performs exactly as promised by AMSAT. Documentation for QUIKTRAK is on the disk in an ASCII file entitled QUIKTRAK/DOC. The instructions for using the program are clear, concise and written for the novice. They explain in understandable non-technical language what the user may expect from the program and the input the program expects from the user.

QUIKTRAK's main menu offers the user several selections:

≡ACTIVITIES≡

- A = SCHEDULE
- B = TRACK
- C = KEPLERIAN FILE
- D = QTH INFO
- E = SAVE DATA
- F = WINDOW TRACK
- G = WINDOW TRACK DATA
- Q = QUIT

Before requesting orbital predictions, the user must input certain information essential to compute the azimuth and elevation settings of the user's antenna. Item 'D=QTH INFO' requires the user to input among other things the station's latitude, longitude and height above sea level. The program also prompts the user to input Keplerian data for each satellite in its inventory. Selection of item 'C=KEPLERIAN FILE' from the main menu, will require manual input from the keyboard

of orbital elements for each satellite. The orbital elements may be obtained from a variety of sources, the most common being the local Packet BBS. This orbital data is generated weekly by AMSAT and usually found in messages entitled '2-line Orbital Elements XXX.AMSAT. Good news about updating orbital elements later.

With QTH info and Keplerian data entered, you're ready to select items 'A=SCHEDULE' or 'B=TRACK' from the main menu. The program's SCHEDULE option prompts the user to select a satellite and beginning date and time. The program then generates a schedule of passes in view of user's QTH. Below is an example of SCHEDULE output:

In this example the satellite is Mir (the Soviet space station) and the starting date/time is 16 AUG 91, 21:41:00 hrs. UTC. Output includes the date and time of AOS (acquisition of signal) and LOS (loss of signal); the maximum elevation and azimuth of antenna at midpoint of pass; and, the orbit number. With the SCHEDULE option the user obtains a one line listing of each pass in view of user's QTH. SCHEDULE output is displayed on the screen, but may be output simultaneously to a printer by pressing the letter 'P' on the keyboard.

The TRACK function will output to the screen and printer data necessary to track a selected satellite as it passes in view of user's QTH. The program will prompt user to select a satellite and a beginning date and time. It then generates tracking data specifying when and where to point the antenna. Below is an example of TRACK output:

Here the selected satellite is AO-13; the starting date/time is 4 AUG 91, 19:13:00 hours UTC. Output includes azimuth and elevation of antenna, range to the satellite in meters, latitude and longitude of the subsatellite point, phase, doppler shift and pointing angle (indicating spacecraft attitude). These are displayed at the time/change angle increments selected by the user.

Another feature of the program which may be selected from the main menu is 'F=WINDOW TRACK'. I have not used this option, but it is handy for those wanting to know if a particular city is in view of the satellite while it is in view of the user's QTH. Item 'G=WINDOW TRACK DATA' on the main menu permits the user to add, delete or modify any data concerning cities.

QUIKTRAK for the Model 4/4p requires the user to manually input the orbital elements from the keyboard, for each satellite in its inventory. This process is tedious and invites human error. Included on the QUIKTRAK disk is a program entitled SATKEPS/BAS, which reads a NASA 2-line orbital element message and automatically

SCHEDULE for satellite:

Mir from: 16AUG91 214100

DATE	AOS	LOS	MAX	LOS DATE	DX/EL	AZ	ORBIT#
17AUG91	0754	0804	0759	17AUG91	28 EL	137	31470
17AUG91	0930	0940	0935	17AUG91	34 EL	330	31471
17AUG91	1107	1117	1112	17AUG91	14 EL	353	31472

N2GGQ TRACKING: AO-13 FROM:04AUG91 191300

DATE	UTC	AZ	EL	RANGE	LNG/LAT	PHASE	DOPPLER	PA
27AUG91	1317:21	217	0	9967	105/ -9	10	+146MHZ	156
27AUG91	1321:43	217	10	10183	102/ -3	12	-402 HZ	146
27AUG91	1326:05	217	19	10558	100/ +2	13	-696 HZ	136

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The PACSAT Beginner's Guide

Want to get on PACSAT?

Don't know how to get started?

Written in a conversational style, this new AMSAT publication is almost like having a PACSAT Elmer on your bookshelf. It takes you from the conception of the store and forward satellite thru to the fine details of PACSAT operation.

You don't have to be an experienced satellite operator to use this booklet. It starts with a description of what a PACSAT station consists of and then, step by step, walks you through receivers/converters, transmitters, antenna and coax selection, preamps, TNC requirements, and finally tracking. Once your station is set up *The PACSAT Beginner's Guide* explains the various software programs needed to operate successfully through the birds. Included is a 5-1/4 inch PC compatible diskette.

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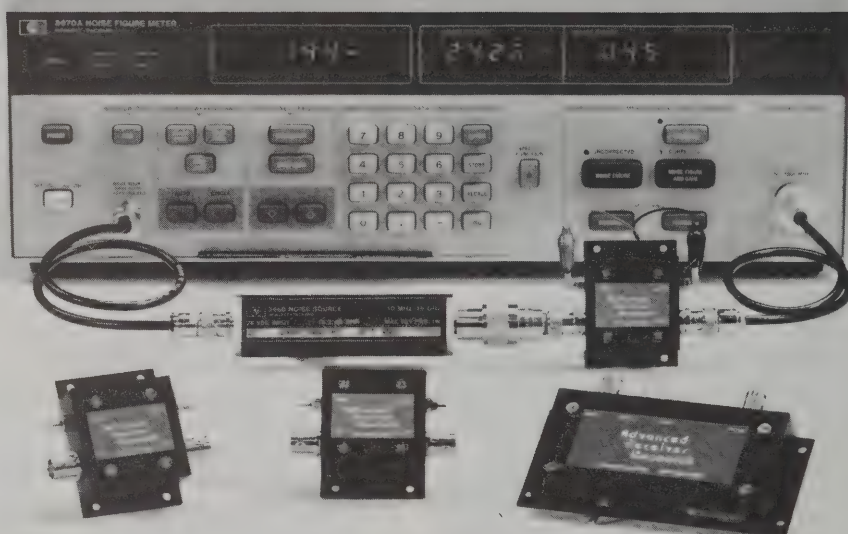
updates orbital data for all 14 satellites in the QUIKTRAK inventory. SATKEPS/BAS requires only that the 2-line orbital element message be saved in an ASCII file entitled SATKEPS/TXT. The program will edit the message, retrieve the data for the designated satellites, and update QUIKTRAK's data file with fresh orbital data.

The Model 4/4p computer is no longer manufactured by Tandy/Radio Shack, but they continue to provide service. *COMPUTER NEWS 80*, published in Casper, WY is a newsletter supporting TRS-80 users and may

be of help in finding a Model 4. The Model 4 is large, old and very slow by today's standards. The computer running QUIKTRAK takes 2-3 hours to produce 30 days of tracking for OSCAR-13. But, for less than \$100 who's in a hurry!■

EDITOR'S NOTE: SATKEPS/BAS was written by Bill Nelson and donated to AMSAT for inclusion with the QUIKTRAK program for the TRS-80. We wish to express our appreciation to Bill for his contribution.

High Performance vhf/uhf preamps



Receive Only	Freq. Range (MHz)	N.F. (dB)	Gain (dB)	1 dB Comp. (dBm)	Device Type	Price
P28VD	28-30	<1.1	15	0	DGFET	\$29.95
P50VD	50-54	<1.3	15	0	DGFET	\$29.95
P50VDG	50-54	<0.5	24	+12	GaAsFET	\$79.95
P144VD	144-148	<1.5	15	0	DGFET	\$29.95
P144VDA	144-148	<1.0	15	0	DGFET	\$37.95
P144VDG	144-148	<0.5	24	+12	GaAsFET	\$79.95
P220VD	220-225	<1.8	15	0	DGFET	\$29.95
P220VDA	220-225	<1.2	15	0	DGFET	\$37.95
P220VDG	220-225	<0.5	20	+12	GaAsFET	\$79.95
P432VD	420-450	<1.8	15	-20	Bipolar	\$32.95
P432VDA	420-450	<1.1	17	-20	Bipolar	\$49.95
P432VDG	420-450	<0.5	16	+12	GaAsFET	\$79.95
Inline (rf switched)						
SP28VD	28-30	<1.2	15	0	DGFET	\$59.95
SP50VD	50-54	<1.4	15	0	DGFET	\$59.95
SP50VDG	50-54	<0.55	24	+12	GaAsFET	\$109.95
SP144VD	144-148	<1.6	15	0	DGFET	\$59.95
SP144VDA	144-148	<1.1	15	0	DGFET	\$67.95
SP144VDG	144-148	<0.55	24	+12	GaAsFET	\$109.95
SP220VD	220-225	<1.9	15	0	DGFET	\$59.95
SP220VDA	220-225	<1.3	15	0	DGFET	\$67.95
SP220VDG	220-225	<0.55	20	+12	GaAsFET	\$109.95
SP432VD	420-450	<1.9	15	-20	Bipolar	\$62.95
SP432VDA	420-450	<1.2	17	-20	Bipolar	\$79.95
SP432VDG	420-450	<0.55	16	+12	GaAsFET	\$109.95

Every preamplifier is precision aligned on ARR's Hewlett Packard HP8970A/HP346A state-of-the-art noise figure meter. RX only preamplifiers are for receive applications only. Inline preamplifiers are rf switched (for use with transceivers) and handle 25 watts transmitter power. Mount inline preamplifiers between transceiver and power amplifier for high power applications. Other amateur, commercial and special preamplifiers available in the 1-1000 MHz range. Please include \$2 shipping in U.S. and Canada. Connecticut residents add 7-1/2% sales tax. C.O.D. orders add \$2. Air mail to foreign countries add 10%. Order your ARR Rx only or inline preamplifier today and start hearing like never before!

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1991 AMSAT Satellite Field Day Results

By Doug Loughmiller, KO5I
AMSAT Chairman of the Board

As I mentioned in the May Edition of the AMSAT Journal, the use of the OSCAR satellites for public service work is a vitally important aspect of the overall operation of the Amateur Satellite Service. We simply can not do enough to bolster our standing in the world of public service, particularly during times of need such as natural disasters or other life threatening emergencies.

In preparation of such service I challenged the members of our organization to use the 1991 Field Day competition as a time to dedicate ourselves to this important and necessary activity. Nineteen groups responded by submitting entries to the first AMSAT Satellite Field Day competition. Many more groups participated in the exercise itself but choose not to submit an entry.

Listed below are the results of the first competition. All 19 groups who submitted entries will receive a certificate of participation. It was my pleasure to award Leanore Guimont, KA6UCD, secretary of the K6HAI field day group with the championship plaque for this year's competition during the AMSAT Annual Meeting in LA on November 9, 1991.

We will sponsor the event again next year and will be announcing the details and rules for the competition in the early part of 1992. AMSAT Vice President of Field Operations, N4IFD will head up the organization of this competition. It is my hope that we will build upon the experience of this year and see many more participants in next year's event. Maybe even with a little luck the competition plaque will migrate eastwards to Texas as I know of one group who intends to put together a full effort to claim the 1992 title! Thanks to all of the participants!■

PLACE	STATION	POINTS
1	K6HAI	960
2	N4IFD	848
3	W6NWX	750
4	AA6NB	732
5	N5BF	556
6	W5IU	554
7	N6JNS	510
8	N4NR	506
9	VE3RAM	504
10	NX2Q	488
11	W5ZDN	482
12	KB9BNR	466
13	N8AM	446
14	K2CT	390
15	WA3NAN	358
16	W1ND	340
17	W6TO	338
18	WA5TWT	304
19	KC4DY	236



No tracking programs necessary while Dennis N4NR and Jack N4MFZ are around.



Antenna array at W5IU



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\$30 in U.S. \$42 elsewhere (U.S. funds) Licensed amateurs or age 65 or over, upon submitting proof of age, may request special dues rate of \$24 in the U.S. \$36 elsewhere in U.S. funds. Persons age 17 and younger may qualify for special rates, write for application.

For postal purposes, fifty percent of dues is allocated to QST, the balance for membership.

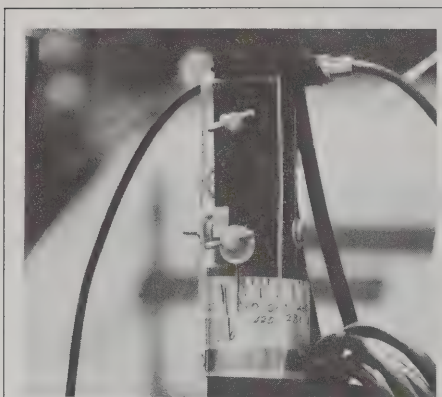
VISA, MC, AMEX, Discover # _____

Signature _____ Expires _____

The American Radio Relay League

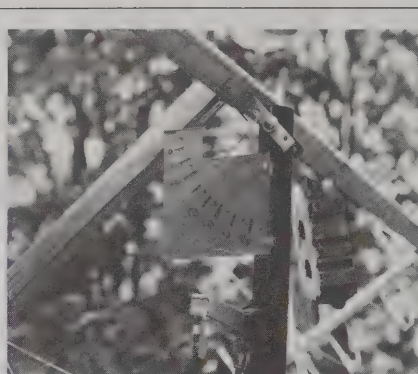
225 Main St. Newington, CT. 06111 USA

AMSAT



Azimuth indicator.

Photo by VE3NPC



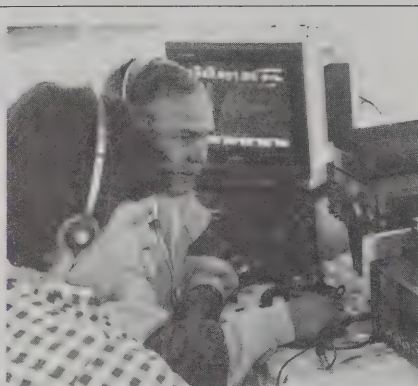
Elevation indicator. Notice the brick used for a counterbalance.

Photo by VE3NPC



VE3RAM Field Day Station.

Photo by VE3NPC



Glenn WB5TUF and Pat W6YEP operating W6TO.

AMSAT News

Election of Board of Directors

The results of the Board of Directors election has been announced. Four seats were up for election this year. A total of 1746 members voted. The results of the balloting are as follows:

Jan King, W3GEY	1451
Bob McGwier, N4HY	1437
Bill Tynan, W3XO	1268
Junior DeCastro, PJ2BJO	1240
Andy MacAllister, WB5ZIB	1237

A two year term of office will be served by King, McGwier, Tynan and DeCastro. MacAllister will serve as alternate.

New Software Available

The AMSAT Software Exchange has three new programs available:

ATARI 8-Bit Tracking Program. This program is the original W3IWI tracking program modified for the ATARI 8-bit series of computers. It runs in ATARI BASIC and has output capability to either screen or printer. No graphics. Documentation is included on the diskette. Requirements include: ATARI 400, 800 w/ATARI BASIC cartridge installed, ATARI 600XL, 800XL, 1200XL, 65XE or 130XE. ATARI 810 or 1050 disk drive or compatible. Printer is optional. \$10 members, \$20 non-members.

STSORBIT: For IBM PC compatibles. This program is designed to track NASA Space Shuttles and other satellites. It displays the orbital position and projected ground track of the shuttle on a global map during a typical NASA mission. This display attempts to duplicate the wall map in NASA's Mission Control Center. NASA ground tracking stations and Tracking Data Relay Satellites are shown on the map if desired. When used with an EGA or VGA monitor, the display is in color. With CGA and HGC systems the display is presented in monochrome. The program supports automatic Keplerian updates (using NASA two-line format) or manual updates. Documentation is contained on the 3.5" diskette. Members and non-members \$10.

UP/DOWN: For IBM PC compatibles. UP/DOWN is and Amateur Radio Satellite Operations Aid program. It provides Uplink to Downlink frequency conversions, technical data, history, beacon frequencies, modes available and other useful information about the satellites. Provisions are included for the user to update the satellites information as deemed appropriate. When used with an EGA or VGA monitor, the graphics display is in color. With CGA systems the display is presented in

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- Complete Arrays • GaAs FET Preamps
- TROPO • EME • Weak Signal • OSCAR •
- Microwave Transverters

902 1269 1296 1691 2304 3456 MHz
2345 LYK45el 1296 MHz 20dBi \$89
1345 LYK45el 2304 MHz 20dBi \$75
3333 LYK33el 902 MHz 18.5dBi \$89

Above antennas kits available assembled.
Add \$8 UPS s/h
Add \$11 UPS s/h West of the Mississippi.

MICROWAVE LINEAR AMPLIFIERS SSB, ATV, REPEATER, OSCAR

2316 PA 1w in 18w out 1240-1300 MHz \$265
2335 PA 10 in 35w out 1240-1300 MHz \$315
3318 PA 1w in 20w out 900-930 MHz \$265
3335 PA 10 in 40w out 900-930 MHz \$320
231NA preamp 0.7dB N.F. 1296 MHz \$90
331NA preamp 0.9dB N.F. 902 MHz \$90

NEW PRODUCT ANNOUNCEMENTS

New Loop Yagi

1845 LY Loop Yagi 1691 MHz 20dBi \$99
945 LY Loop Yagi 3456 MHz 20dBi \$89
Above antennas assembled and tested

New Preamps

131NA 0.7dB N.F. 12 dB 2.3 GHz \$140
181NA 20 0.8dB N.F. 20 dB 1.69 GHz \$140
SLNA 1.0dB N.F. 10 dB 2-2.7 GHz \$150

New Wideband Power Amplifiers

2370 PA 3w in 70w out 1240-1300 MHz \$695
2340 PA 2w in 35w out 1240-1300 MHz \$355
2318 PAM 1w in 18w out 1240-1300 MHz \$205

Rack mount Amplifiers for repeater use available.

NO TUNE MICROWAVE LINEAR TRANSVERTERS

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Available in kit form or assembled/tested

- 903 1269 1296 2304 3456 MHz
- microstrip filters eliminate tune-up
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- low profile packaging, mast mountable

All active equipment - 13.8V

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monochrome. Memory requirements are minimal by today's standards. For the operator just getting started in Amateur Radio Satellites, this program provides a ready reference for valuable information about all the birds in one convenient place. Members and non-members \$10.

Proceedings for Sale.

The 260 page Proceedings for the AMSAT-NA Ninth Space Symposium are available from the AMSAT Office. They include a wide variety of subjects on papers presented during the three day meeting. Of particular note are the papers presented on the Phase 3-D project, Digital Video through satellites as well as a collection of papers presented for the Educational Workshop - focusing on the use of Amateur Satellites in the classroom. The Proceedings are available for \$12.00 in the U.S. Add \$3.00 in Canada, \$5.00 Europe and South America and \$10.00 elsewhere.

Attention Foreign Life Members

For those AMSAT-NA Life Members who live outside the United States, it is possible to receive the AMSAT Journal via Air Mail (rather than surface) for an additional \$20 U.S. per year. Contact AMSAT HQ for more details.

She has only got two hands

Martha Saragovitz, the AMSAT Office Manager, wishes to remind AMSAT members that she is the only person in the office and that from time to time work can get backed up. Martha is in the office from 10:00 AM to 6:00 PM, Monday thru Friday Eastern time. Occasionally she is unable to answer the telephone while running to the Post Office to mail out member requests for literature and software. Your understanding is appreciated.

AMSAT Board of Directors Meeting

The AMSAT Board of Directors met on Sunday November 10, 1991 the day following the AMSAT Symposium and Annual Meeting. Board Members in attendance were:

Doug Loughmiller, KO5I
Jan King, W3GEY
Tom Clark, W3IWI
Bill Tynan, W3XO
Bob McGwier, N4HY
Junior DeCastro, PJ2BJO
John Champa, K8OCL

Also in attendance were:

Art Feller, KB4ZJ Treasurer
Roy Soifer, W2RS Senior Vice President
Martha Saragovitz, Corporate Secretary

The following is a summary of the meeting General Manager Doug Loughmiller, KO5I, gives a synopsis of the financial report.

Membership renewals are strong, however, we are behind on new members. Software sales are 10% behind projections at this time. More focus should be put on fund raising by the General Manager. We are behind in hamfest income. We are doing well with the Journal. Revenue contributions by the other publications is ahead of projections. Field Ops budget has exceeded the the plan for FY91. Expenditures on Phase 3-D are under budget. Manned Space has spent its money and there are no more expected major expenditures. WARC 92, we have spent 25% and expect no further major expenditures. GM budget is on track.

AMSAT Journal - Martha found a printer in the D.C. area, Executive Printing, in Beltsville, MD that have said they would print the Journal at a 40% reduction in present cost.

As of this report, income for the year is \$234,186 and spent \$237,114 for a deficit of \$2,928.

Fund raising efforts: ARRL has pledged to raise funds to defray direct launch expenses. The fund raiser will be in the second quarter (after WARC 92). Dave Sumner will have a direct hand and it should commence in early April. It needs to get well off before Dayton.

KO5I is directed to talk to Dave Sumner and Jay Holliday to get Dick Baldwin, ARRL, DARC, to get a face to face meeting where President of IARU request JARL monies for 3-D.

N4HY, moves closed session, W3XO, seconds to discuss personnel matters.

Ken Nichols, KD3VK, gave a presentation on the site of the 1992 annual meeting. He proposed Intelsat in Washington DC.

The office of Chairman of the Board was reestablished to give Doug Loughmiller a position befitting his standing in the organization and one that which will convey this standing to outside organizations he will be contacting in his fund raising efforts. Both Doug and the Board agreed that it would aid the fund raising efforts if he were freed from administrative duties. In addition to the Chairman of the Board position, he was given the title Executive Director.

In accord with the decision to enable Doug to concentrate on fund raising, especially in support of Phase 3-D, Bill Tynan, W3XO, agreed to serve as President and Ray Soifer W2RS agreed to serve as Executive Vice President. Keith Pugh W5IU was elected to serve as Operations Vice President. Jan King W3GEY was re-elected to the position of Vice President for

Engineering. Art Feller, KB4ZJ, Treasurer, Martha Saragovitz, Secretary. With the concurrence of the Board, W3XO made the following appointments: Mike Crisler, N4IFD, VP Field Operations, Andy MacAllister, WA5ZIB, VP of User Services, Drew Deskur, KA1M, VP of Publications, all were elected unanimously.

Phase 3-D report:

The need for insurance for Phase 3-D was raised. One of the concerns is the potential liability as a result of possible RF radiation hazard during ground testing. The need for launch insurance and launch liability insurance was also voiced. The need for insurance will of course raise the cost of the Phase 3-D program.

The funding requirements for Phase 3-D were discussed. The overall requirement for funding by AMSAT-NA is approximately \$1.5M. Dick Daniels will be asked to provide a funding profile but the immediate need for funding was enumerated as follows:

Material for aluminum rings \$20,000
GPS receiver \$7,200
Spacecraft LAN support equipment \$10,000

A transition from Telemail for electronic communications was discussed. W3IWI has declared successful the experiment of utilizing an InterNet E-mail distribution system. N4HY, moved, K8OCL, seconded that AMSAT allocate a sum not to exceed \$10,000, to purchase sufficient computing services to replace the experimental system run by W3IWI and we place this computer on site at UCSD under the operational control of Brian Kantor, WB6CYT.

K8OCL, moves that as sum not to exceed \$6000 be allocated for computing equipment for the AMSAT office and for KO5I to support fund raising activities by the Chairman and member services by the officer manager. N4HY, seconds. Passed unanimously.

Dennis Wingo, KD4ETA, and Cheryl Bankston, make a presentation about SEDSAT. SEDSAT Project is interested in the following: They want Quadron software support, 70 cm antenna design for the spacecraft, Mode A technical review and consultation, 70 cm FSK 9600 bps transmitter technical review and consultation, Detroit OSCAR Users group support approved by AMSAT-NA, etc. N4HY moves, K8OCL seconds. Passes unanimously. N4HY, seconded by KO5I, that an official recognition and congratulations be extended to Dennis and Cheryl on how much has been accomplished in a year. Passed unanimously.

KO5I and W3GEY are directed to reply

to Interferometrics letter, and to work out methods for technology transfer from ITAMSAT, and UNAMSAT back to AMSAT as per license followed by transfer to Interferometrics.

W3XO is directed to fix the technical errors in the Surrey Satellite MOU to transfer the PACSAT software sourcecode. and to send two signed copies.

The Board officially recognized the fine job Martha has done as Office Manager this year.

DOVE status report. DOVE will be on 2 meters in a week. Voice messages are in the can. Bob understands the urgent need to get this bird on the air and will make every effort to do so.

Manned space report: QSL's are now in hand. Goddard ARC is in the process in reviewing the logs in preparation of sending out the cards.

Discussed the FCC petition for Technician and up operation of Space Stations. AMSAT will go forward in submitting that proposal. AMSAT will support the Central States VHF society doing an FCC briefing.

Follow on Microsat Status: AMSAT-CE wants to do a microsat. Chilean Air Force is involved, and this connection must be

investigated before we proceed. W3IWI will do so in a trip to Chile.

A discussion of SARA, BADR, and others led to a recommendation:

We encourage amateur scientific satellites from any source so long as they meet the following criteria:

- (1) data be publicly available with published formats (preferably before launch)
- (2) there be an amateur radio operator involvement and only licensed amateurs operate the control stations for these satellites.
- (3) frequency coordination before launch with amateur satellite community.
- (4) notification of official bodies via IFRB filings in adequate time for comment before launch. Moved by W3IWI, seconded by N4HY. Passed unanimously.

W3IWI moves that we write a letter to FCC drawing attention to the fact that the French satellite SARA had an IFRB filing that did not appear until 8 months after filing (i.e. after launch). This is to be understood as NOT a complaint against SARA but about timeliness from IFRB. N4HY second. Passes unanimously.

Naval Postgraduate School DSSS satellite seems to meet these requirements

after the notifications are made.

W3XO suggested the inclusion of UV sensors on some future Amateur Satellite.

Bob Cooper, K6EDX/VP5D/ZL4AAA has proposed to put a number of beacons on six meters around the world. Robots. W3XO suggests that the data from these beacons could be collected by existing Amateur Store and Forward Satellites (i.e. PACSAT). Those knowledgeable of these satellites saw no reason why this could not be done.

We accept the accounting firm's audit and rehire them. KO5I and N4HY second. Passed unanimously.

Meeting adjourned.

A Beginners Guide to OSCAR 13, by Keith Berglund, WB5ZDP, is a step-by-step guide to getting started on OSCAR 13. \$7 in the U.S., \$8 in Canada and Mexico, \$10 elsewhere. Call AMSAT Hq., 301-589-6062 to order.

Satellite Orbital Elements

By Dick Campbell, N3FKV

Satellite	AO-10	UO-11	RS-10/11	AO-13	FO-20	AO-21	RS-12/13
Catalog Number	14129	14781	18129	9216	0480	21087	21089
Epoch Time	91307.09985695	91314.56733190	91314.91225783	91310.60757627	91291.88220393	91311.95334980	91313.12650755
Element Set	708	126	928	287	243	176	176
Inclination	025.7973	97.8796	82.9250	56.7146	99.0429	82.9436	82.9236
RAAN	116.5596	353.9670	310.4302	62.2382	250.6443	127.3792	356.6579
Eccentricity	0.6075212	0.0013467	0.0012758	0.7235702	0.0541460	0.0033929	0.0027791
Arg of Perigee	289.8430	61.7760	133.1543	269.3641	21.3122	217.9954	235.6589
Mean Anomaly	016.7190	298.4924	227.0694	15.2670	340.9627	141.8815	124.1938
Mean Motion	02.05888636	14.67693320	13.72229859	2.09704227	12.83191601	13.74426239	13.73940761
Decay Rate	8.04e-06	3.595e-05	1.75e-06	-7.2e-07	4.7e-07	2.09e-06	1.89e-06
Epoch Rev	3511	41091	21971	2601	7942	3877	3804
Checksum	511	091	971	601	942	877	804
Satellite	UO-14	AO-16	DO-17	WO-18	LO-19	UO-22	MIR
Catalog Number	20437	20439	20440	20441	20442	21575	16609
Epoch Time	91313.20776370	91303.43482414	91307.74593498	91304.98295464	91305.43986181	91307.73916569	91315.05220663
Element Set	476	320	323	316	318	029	881
Inclination	98.6610	98.6645	098.6600	98.6636	98.6643	098.5298	51.6039
RAAN	31.7694	22.4773	026.8293	24.1375	24.6714	020.5310	270.1991
Eccentricity	0.0011502	0.0011664	0.0011663	0.0013176	0.0012597	0.0007566	0.0005474
Arg of Perigee	98.7680	125.6497	116.7080	122.8434	120.4568	261.2275	75.2482
Mean Anomaly	261.4795	234.5830	243.5841	237.4089	239.7972	098.8609	284.9099
Mean Motion	14.29352727	14.29403387	14.29521455	14.29532630	14.29613132	14.36278531	15.58265228
Decay Rate	1.109e-05	8.53e-06	1.632e-05	8.68e-06	9.14e-06	8.44e-06	5.3173e-04
Epoch Rev	9370	9231	9293	9254	9261	1574	2806
Checksum	370	231	293	254	261	574	806

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The versatile DSP-2232 (above) is simply the most powerful multi-mode controller available to amateurs. It features Digital Signal Processing modems, dual simultaneous ports, all known amateur digital modes, Packet and AMTOR mailboxes, and much more.

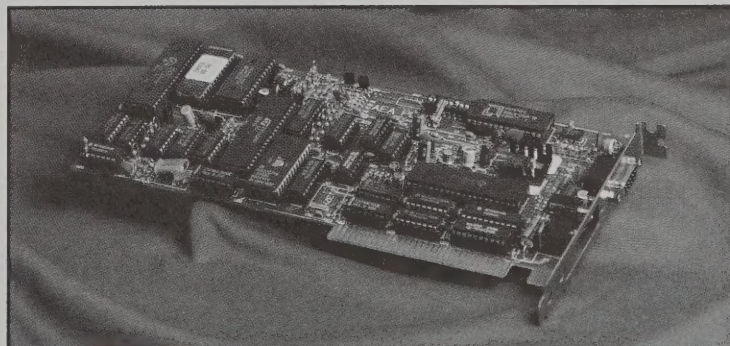
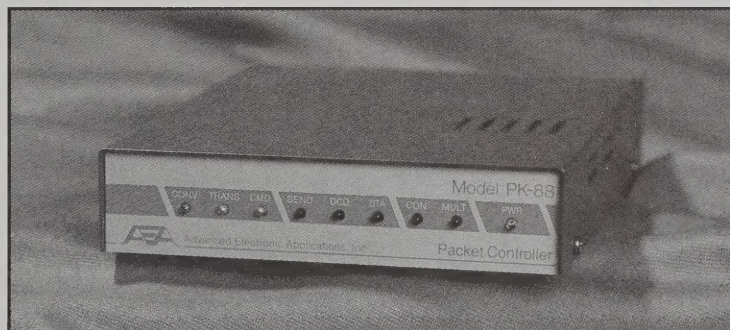
The legendary PK-232MBX (top right) has long been the most popular data controller ever, and is still going strong. Includes: Chebyshev filter design, Host Mode, Signal Identification mode and more. With features like these, no wonder it's number 1.

For Packet only, the PK-88 (center) and its PC-compatible plug-in counterpart, the PCB-88 (bottom right) offer AEA's famous Host Mode, Packet maildrop, KISS mode, lithium battery-backed RAM...the list goes on and on.

When hams think of Packet, they think of AEA.

AEA is Packet...plus!

For complete information on these or any other AEA products, call the toll-free Info-Line at (800)432-8873.

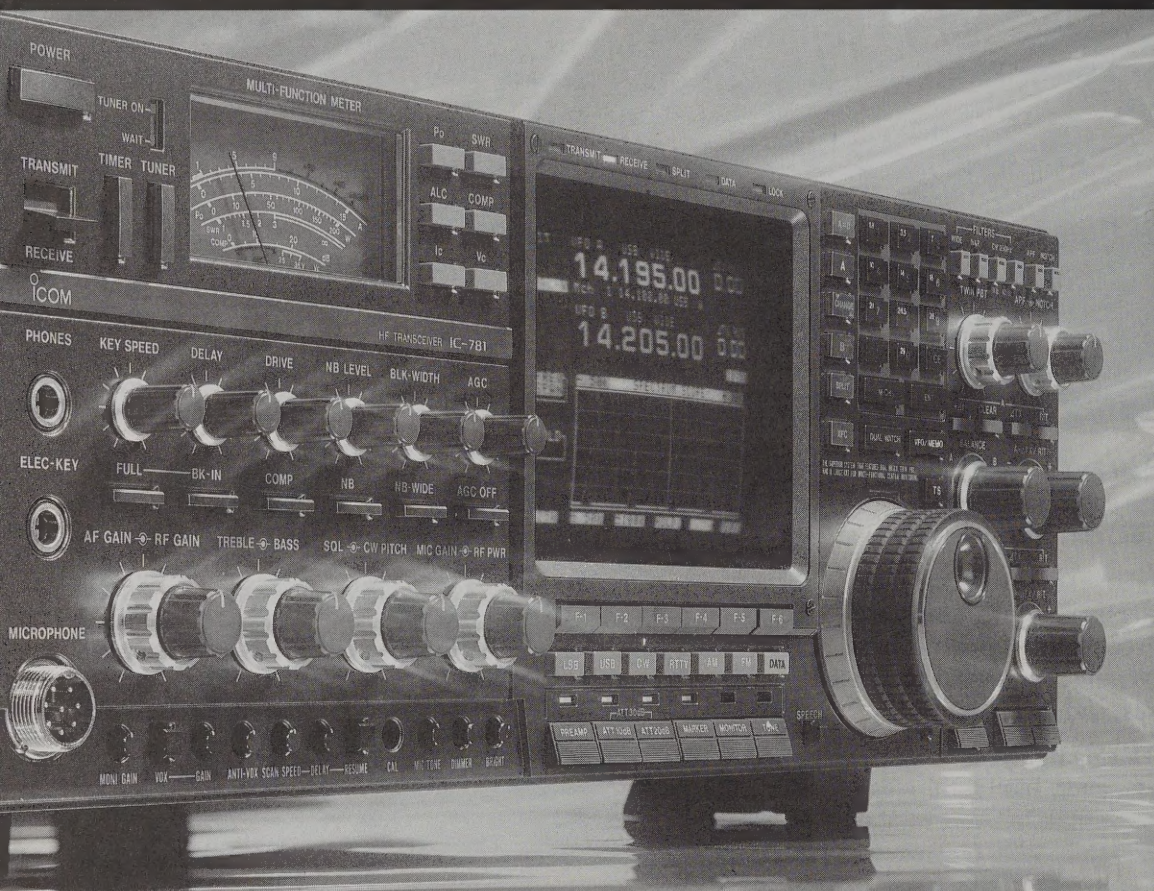


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HF TRANSCEIVER

Nothing compares to the captivating experience of operating the finest transceiver on the market, the IC-781. The exhilaration of operating the IC-781 is matched only by the luxury of its crystal clear communications.

Designed for rigorous operation, the IC-781 is the result of extreme dedication, exceptional craftsmanship and precision engineering. The IC-781 fuses the perfect blend of features such as driving power, incredible clarity, a Multi-Function CRT Display, Spectrum Scope and Icom's exclusive DDS System to achieve unbeatable HF operation worldwide.

Whether you aspire to DX, contest or enjoy legendary performance, the IC-781 inspires countless hours of devoted attention. Backed by a service commitment second to none, four factory service centers and a one-year factory warranty, the IC-781 characterizes Icom's dedication to excellence.

For full details call the Icom Brochure Hotline at 1-800-999-9877.

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All stated specifications are subject to change without notice or obligation.
All ICOM radios significantly exceed FCC regulations limiting spurious emissions. 781791

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